

Presentation to the Exploration Transportation Systems Strategic Roadmap Committee



Steve Cook

February, 2005







# **Briefing Purpose**



# Present a strawman space transportation roadmap, philosophy and methodology for committee consideration



# **Agenda**



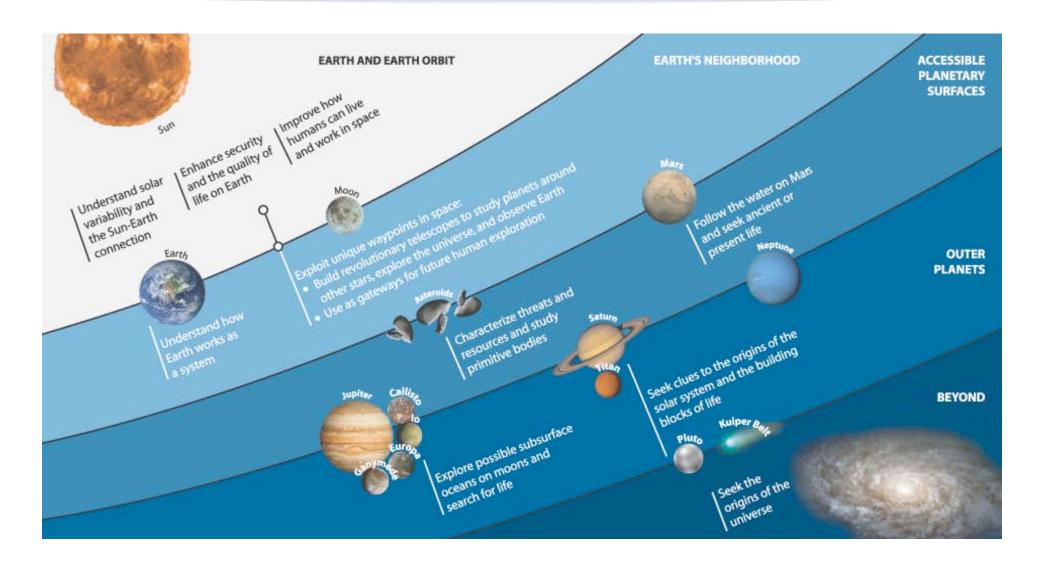


- Scope of Exploration Transportation
- Space Transportation Needs by Spiral
  - Approach
  - Capability vs. Mission Need
  - Potential Themes
- Strawman Space Transportation Roadmaps



# **Potential Range of Space Transportation Missions**

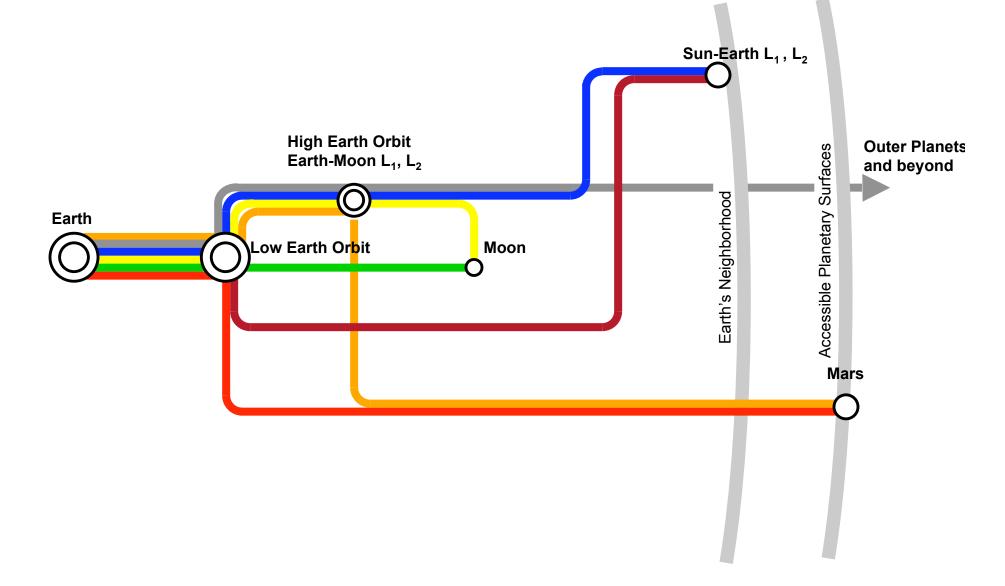






# **Exploration Transportation Routes**

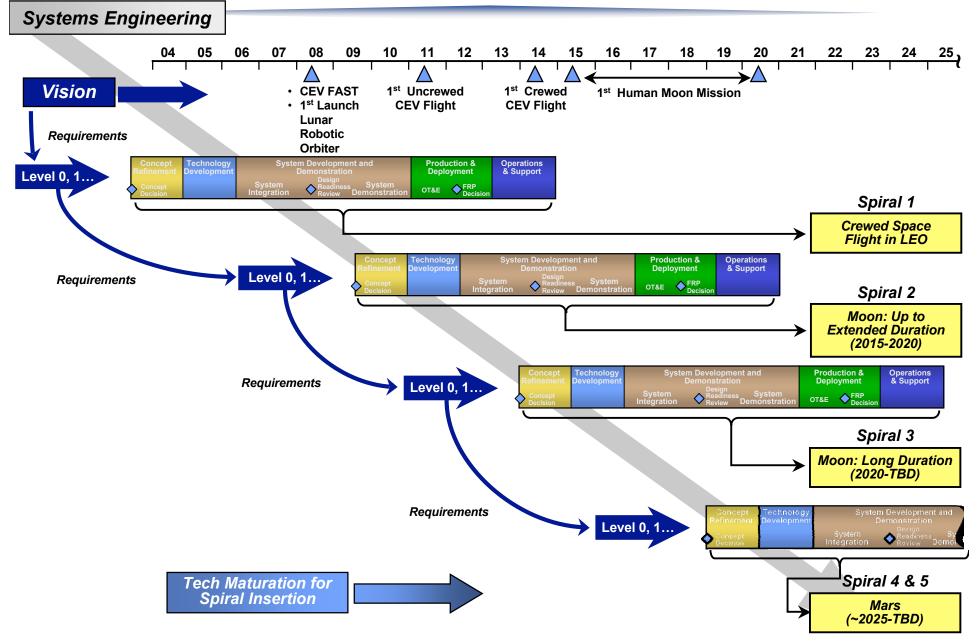






## **Acquisition Timeline**







# **Agenda**



- Scope of Exploration Transportation
- Space Transportation Needs by Spiral



- Approach
- Capability vs. Mission Need
- Potential Themes
- Strawman Space Transportation Roadmaps



# **Approach**



- Developed a transportation function vs. capabilities matrix for each Spiral.
- Within each matrix, transportation capabilities were assessed to be probable, possible, or not applicable for included mission phases.
- Themes and capabilities phasing across and within all Spirals were then derived from the matrices.



# **Transportation Function Definitions**



- Earth to Orbit Pre-launch through ascent to low Earth orbit
- Earth Orbital Earth orbit phase of all Spirals and missions (including reentry from orbit)
- ◆ Earth to Moon Transfer from Earth orbit to Lunar surface and surface operations (includes intermediate points such as L1, Lunar orbit, etc.)
- Moon to Earth Return Ascent from Lunar surface to recovery at Earth's surface (includes return from intermediate points such as L1, Lunar orbit, etc.)

- ◆ Earth to Mars Transfer from Earth orbit to Mars surface and surface operations (includes intermediate points)
- Mars to Earth Return Ascent from Mars surface to recovery at Earth's surface (includes return from intermediate points)
- Solar System Includes all non-Lunar and non-Mars science and exploration missions



# **Agenda**



- Scope of Exploration Transportation
- Space Transportation Needs by Spiral
  - Approach
- Approa
  - Capability vs. Mission Need
  - Potential Themes
  - Strawman Space Transportation Roadmaps



# **Key Transportation Capabilities**



- Transportation Elements Architecture level building blocks (systems) that require supporting systems / technologies / capabilities
- Propulsion Systems Supporting propulsion technologies and capabilities
- Vehicle Systems Supporting vehicle technologies and capabilities (non-propulsion)
- Human Systems Systems, technologies and capabilities that support human space flight
- Operations Pre-launch, launch and mission operations technologies and capabilities



**Space Transportation Needs Assessment** 

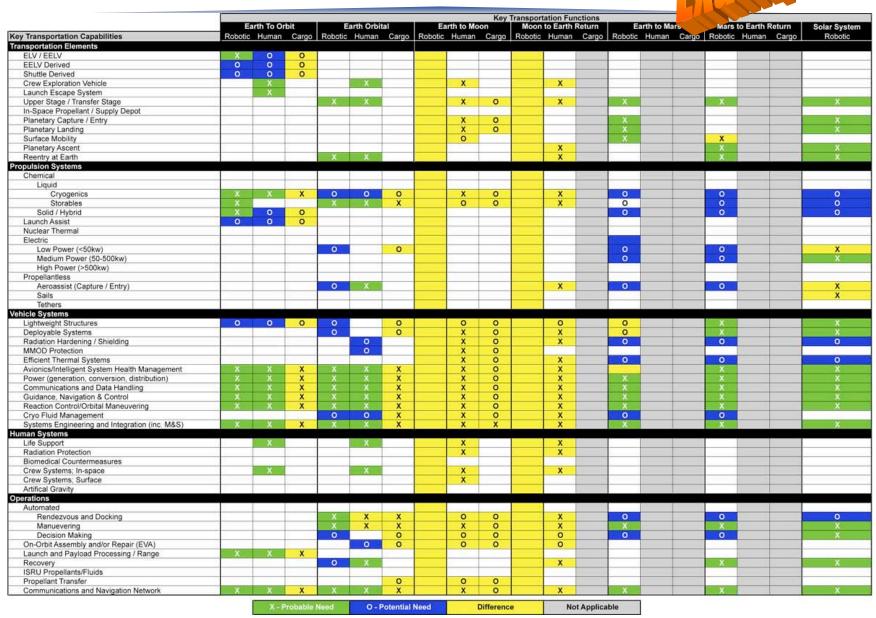
Spiral 1





## **Space Transportation Needs**

Difference Between Spiral 1 and 2





**Space Transportation Needs** 

Spiral 2





# **Agenda**



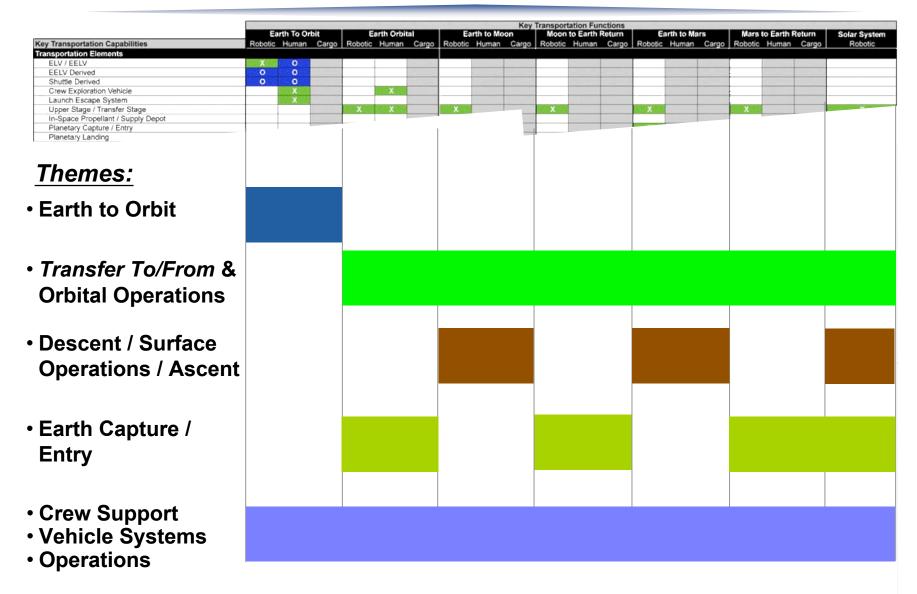
- Scope of Exploration Transportation
- Space Transportation Needs by Spiral
  - Approach
  - Capability vs. Mission Need
  - Potential Themes
- Strawman Space Transportation Roadmaps



## **Theme Area Development**



Mapping to Capability Matrix





#### **General Observations**



- Earlier Spirals exercise, to varying extent, most technologies needed for Mars exploration missions
  - Many must be enhanced to meet later Spiral requirements (i.e., cryo fluid mgmt, radiation shielding, etc.)
- Each Spiral also requires some new capabilities that were not required in earlier Spirals
- Economy may be realized by building later Spiral requirements into new elements for that Spiral.

6815.18



## **Theme: Earth to Orbit**



- Current ELV's
  - Are likely to be able to satisfy all robotic and some cargo missions across all Spirals
  - May satisfy Spiral 1 with modifications for human rating
- Shuttle hardware/systems may possibly be utilized in multiple applications
- Commercial capability may be able to satisfy some lift requirements (e.g., propellant)
- Spiral 1 may require a new upper stage for CEV launch
  - May initially use current engine designs
  - May also have applicability (e.g., cargo, in-space transfer) in later Spirals
- Spirals 2 and 3 may require enhanced launch capability, unless a significant orbital assembly capability is developed
- Spiral 4 will likely require significantly greater Initial Mass to Low Earth Orbit (IMLEO) than Spiral 1, 2 or 3
  - This could be satisfied by heavier lift vehicles, propellant depots, more efficient launch/on-orbit assembly capability, etc.





Crew Exploration Vehicle

#### Options bounded as:

- Basic CEV capability provides crew habitat for launch, minimal delta-V capability for orbit maneuvering and de-orbit, and reentry
- Full CEV capability provides basic CEV capabilities, plus habitat function for in-space transfer and return, and trans-Earth injection delta-V
- Likely to be an evolution in CEV requirements across Spirals (TPS, propulsion capacity, lifetime, etc.)
- Automated rendezvous and docking is required across all Spirals
- CEV propulsion may require cryo-fluid management capabilities
- Lunar CEV may be capable of satisfying human ETO and return requirements for Spiral 4/5





#### Transfer Stages

- Spirals 2 and 3 will likely require new capabilities:
  - A new in-space engine may be required
  - May require progressively larger stages (and corresponding larger lift capability) or multiple stages
  - May utilize non-nuclear advanced propulsion options
- Spiral 4/5 may require significantly larger / multiple stages earlier
   Spirals
  - Likely even if an orbital assembly capability or advanced propulsion is developed.





Nuclear Thermal Propulsion

- Lunar cargo mission in Spiral 3 may be used to demonstrate Nuclear Thermal Propulsion (NTP) system capabilities.
- Spiral 3 technologies provide basis for Spiral 4/5 highpower NTP propulsion options.
- NTP potentially reduces IMLEO requirements and / or improves trip time compared to all-chemical propulsion mission options.
- NTP ground test facilities must be addressed.





#### Electric Propulsion

- Low to medium power Electric Propulsion (EP) systems support robotic solar system exploration across all Spirals
- Reusable low- to medium-power Solar EP systems reduce propellant requirements for Spiral 3 in-space tugs and lunar cargo
  - Evolve from current kW-class EP system technologies.
- High power Nuclear Electric Propulsion (NEP) systems reduce IMLEO for Spiral 4/5 cargo (Mega Watt-class) and piloted (Multi-Mega Watt-class) missions
- Possible options for high-power NEP have been identified:
  - Achieve high power by clustering low- to medium-power electrostatic thrusters (increases propulsion system mass and complexity)
  - Develop high-power, high-thrust density electromagnetic thrusters (currently at low TRL)
- Facility requirements for high-power / long-life EP ground tests must be addressed





Other Advanced Technology Options

- Advanced In-Space Propulsion Technology (APT) includes aeroassist, solar sails, & tethers
- Flight Demonstration is likely a prerequisite for infusion of these technologies
- APT enables cargo and robotic missions with higher payload mass fraction than conventional chemical systems for all Spirals
- APT has the potential to provide improved performance within a Spiral as the products of a technology maturation program are delivered
- APT flight demonstration may be achieved in conjunction with the robotic exploration



## Theme: Descent / Surface Operations / Ascent



Entry and Landing

- Propulsion requirements will likely be driven by architecture decisions
- Landers for Spirals 2 and 3 may be common, particularly when cargo is pre-deployed for Spiral 3
- Spiral 3 and subsequent Spirals may have unique precision landing requirements
  - Based upon need to rendezvous with pre-deployed surface assets (ballistic landing for Spiral 3 and aeroassist for Spiral 4/5)
- Spiral 4/5 may require significantly larger landers (and corresponding greater initial mass in orbit) than Spirals 2 and 3
- Spiral 4/5 may have unique requirements based upon selection of the propulsion option, including potential for in-situ resources utilization



## Theme: Descent / Surface Operations / Ascent



Ascent Propulsion

- State-of-the-Art lander technology may be applicable for some robotic and cargo missions across all Spirals
- Spiral 1 has only robotic ascent requirements, which can be addressed using SOA propulsion
- Overall transportation architecture (e.g., common habitat/split habitat) may drive ascent requirements
- Ascent technologies may be impacted by choice of propellant and the potential use of in-situ resources
- Spiral 4/5 may require significantly larger ascent (and corresponding greater initial mass in orbit) than Spirals 2 and 3, even if advanced chemical propulsion is developed



## **Theme: Earth Capture / Reentry**



- Spirals 1 through 3 may likely have little or no Earth return requirements beyond those already addressed using SOA technologies
- ◆ Spiral 4/5 may have unique Earth return requirements (material, etc.) for aeroentry at Earth, depending on the magnitude of the entry velocities



## **Cross Cutting Theme: Crew Support**



- Technology advancement may not be required for Spiral 1.
- Advancements in radiation protection may be required for Spiral 2 and beyond
- ◆ Longer duration missions (late Spiral 2, Spiral 3) may benefit from closed loop Environmental Control & Life Support Systems (ECLSS); required for Spiral 4/5
- Understanding the transportation system implications of artificial gravity or biomedical countermeasures is needed prior to implementation on Spiral 4/5
- Artificial gravity, if required, is a significant driver to transportation system design
- Robust, highly reliable ECLSS, including in-flight repair capability is critical



## **Cross Cutting Theme: Vehicle Systems**



- Vehicles systems include lightweight structures, deployable systems, radiation and MicroMeteoroid and Orbital Debris (MMOD) protection, GN&C, TPS, etc
- Depending on CEV architecture, SOA vehicle system technologies may be appropriate for Spiral 1
- System technology improvements may be necessary to meet the requirements of later Spirals



## **Cross Cutting Theme: Operations**



- Limitations in launch vehicle lift capability will likely drive in-space assembly requirements
- Spiral 4/5 trip times and communication lags for human flight may require a high degree of mission autonomy
- Operational complexity will increase with mission duration
- ◆ The amount of in-space infrastructure (depots, assembly, communications, etc.) will increase for later Spirals



## **Cross Cutting Theme: Operations (cont'd)**



 Spirals 1 through 3 will likely have no basic requirement for a propellant depot, but a depot may provide some advantages, including potential commercial participation, as early as Spiral 3

Solar Array

♦ If architecture studies indicate the desirability of depots in Spiral 4/5, early consideration should be given to demonstration during Spirals 2 and 3

H2 Tank

 Spiral 4/5 will have larger propellant / mission requirements that may make propellant / supply depot architectures viable



# **Agenda**

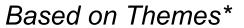


- Scope of Exploration Transportation
- Space Transportation Needs by Spiral
  - Approach
  - Capability vs. Mission Need
  - Potential Themes

Strawman Space Transportation Roadmaps



# Roadmaps





- Earth to Orbit
- Transfer To and Orbital Operations



- Destination Orbital Operations and Transfer From
- Earth Capture / Reentry







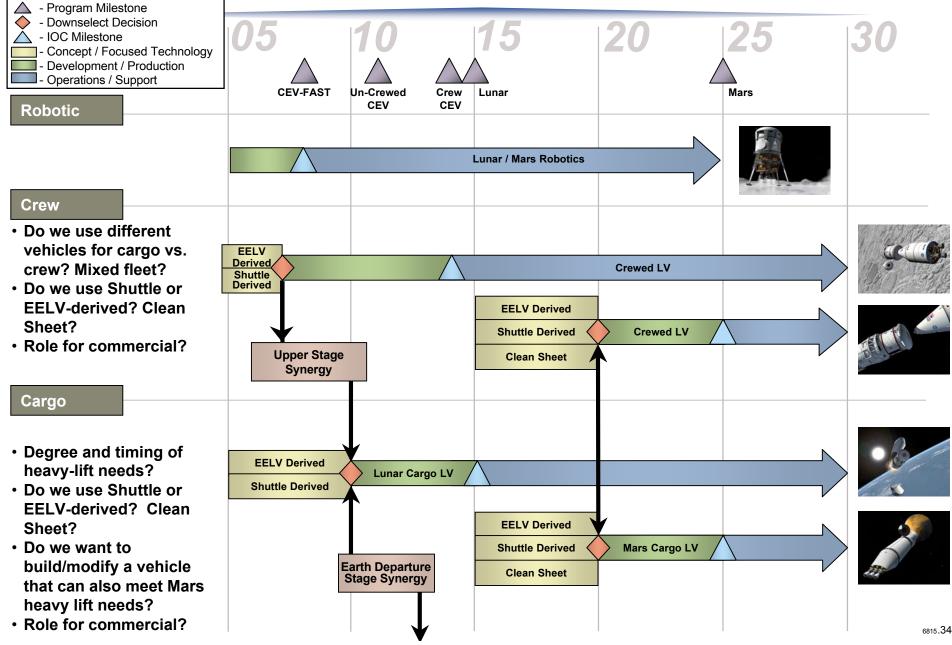


<sup>\*</sup> Integrated the Crew Support, Vehicle Systems and Operations Themes due to their cross-cutting nature



# **Earth to Orbit Roadmap**

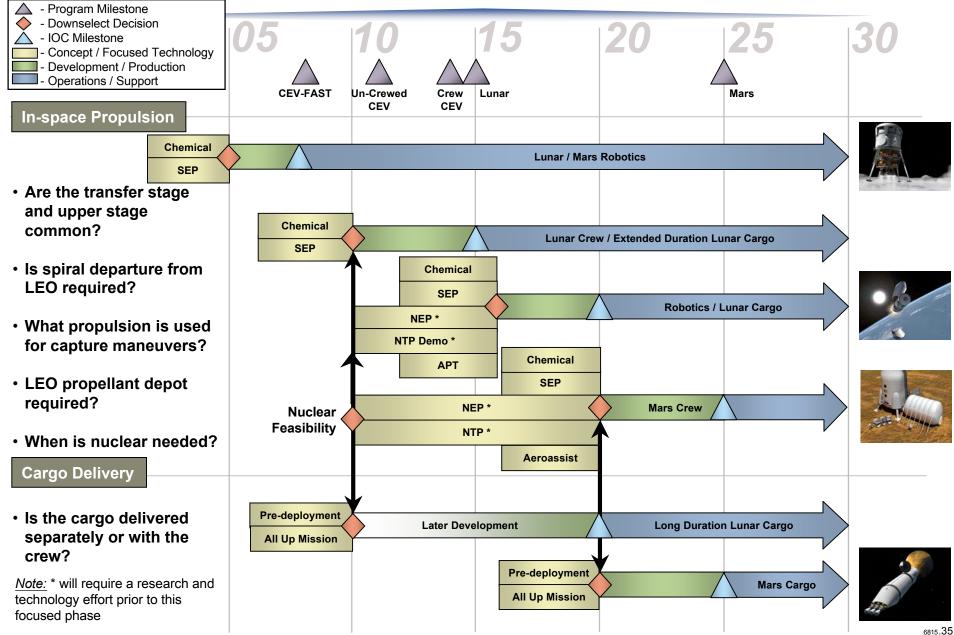






#### **Transfer To and Orbital Operations Roadmap**

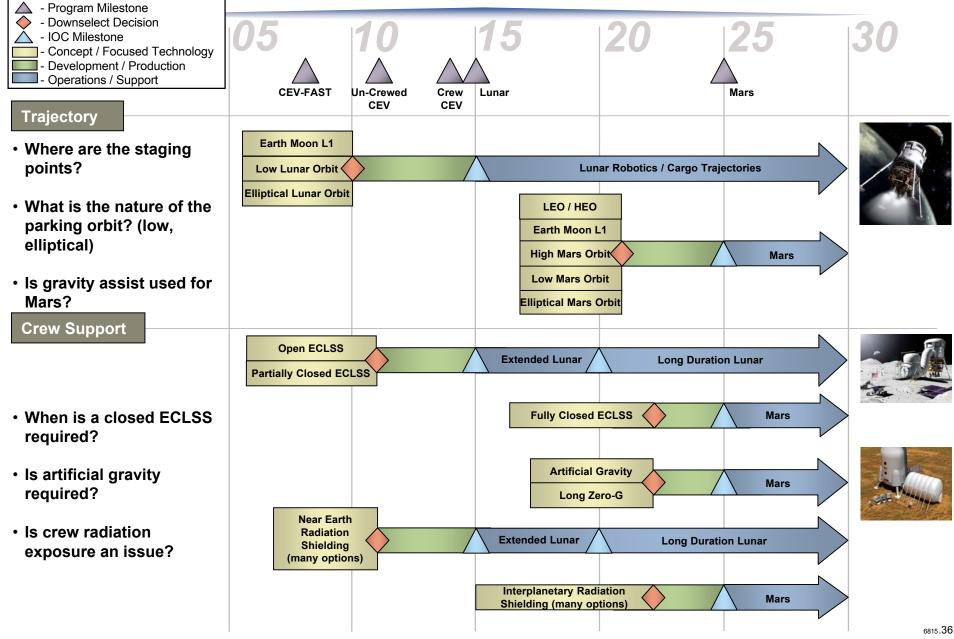






# Transfer To and Orbital Operations Roadmap (cont'd)

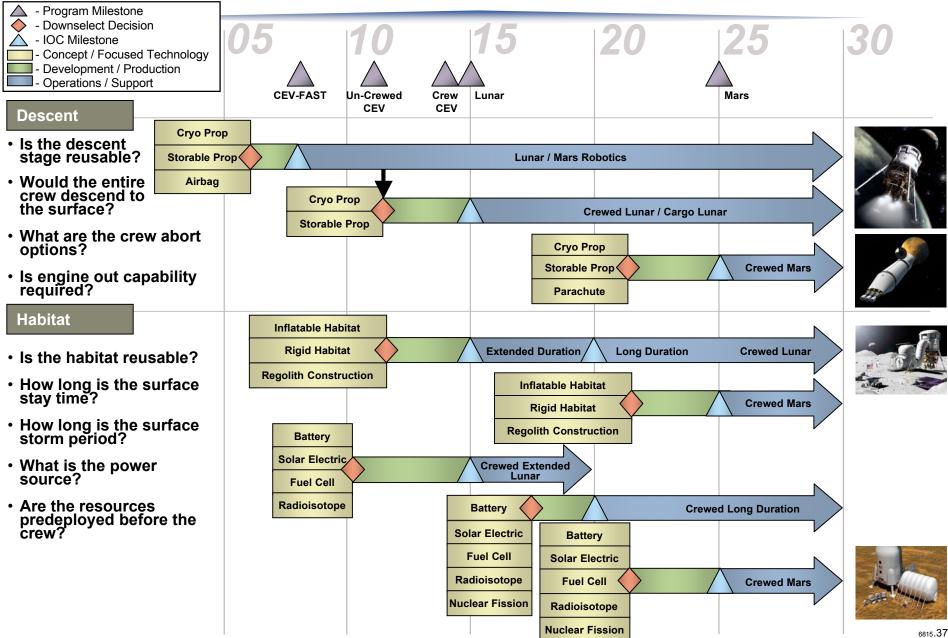






#### **Descent / Surface Operations / Ascent Roadmap**

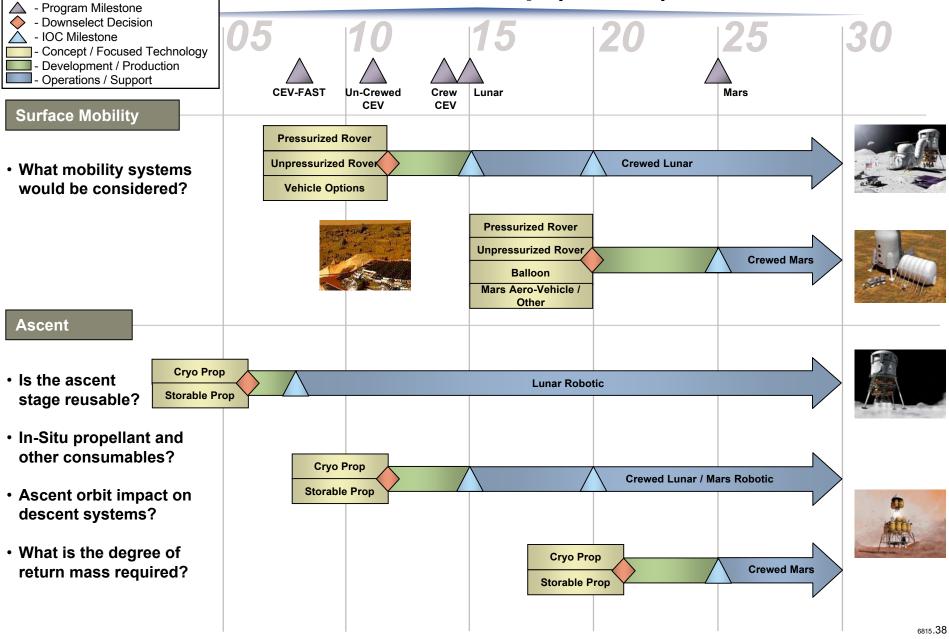




NASA

# Descent / Surface Operations / Ascent Roadmap (cont'd)



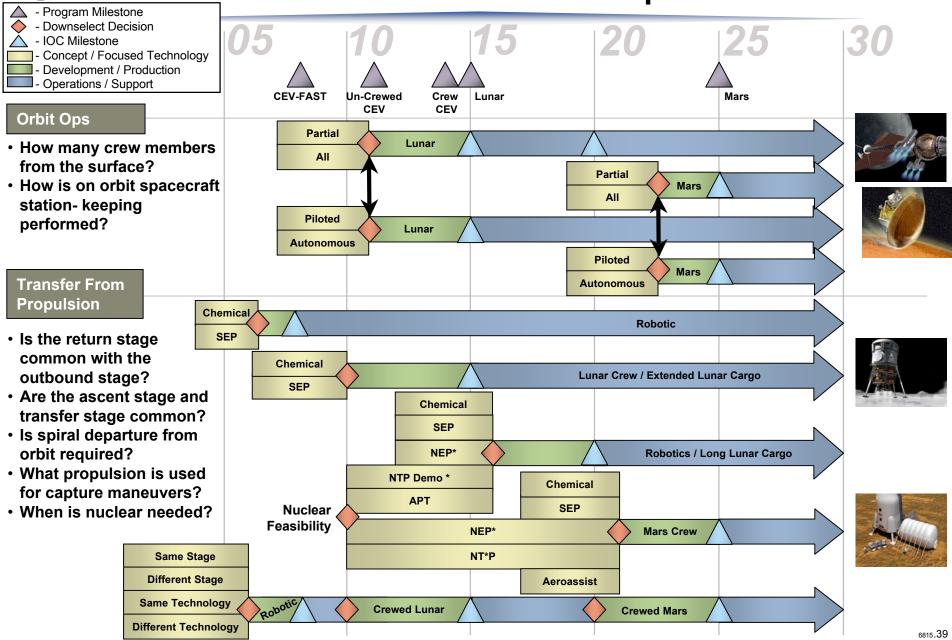


NASA

**Destination Orbital Operations and** 

**Transfer From Roadmap** 



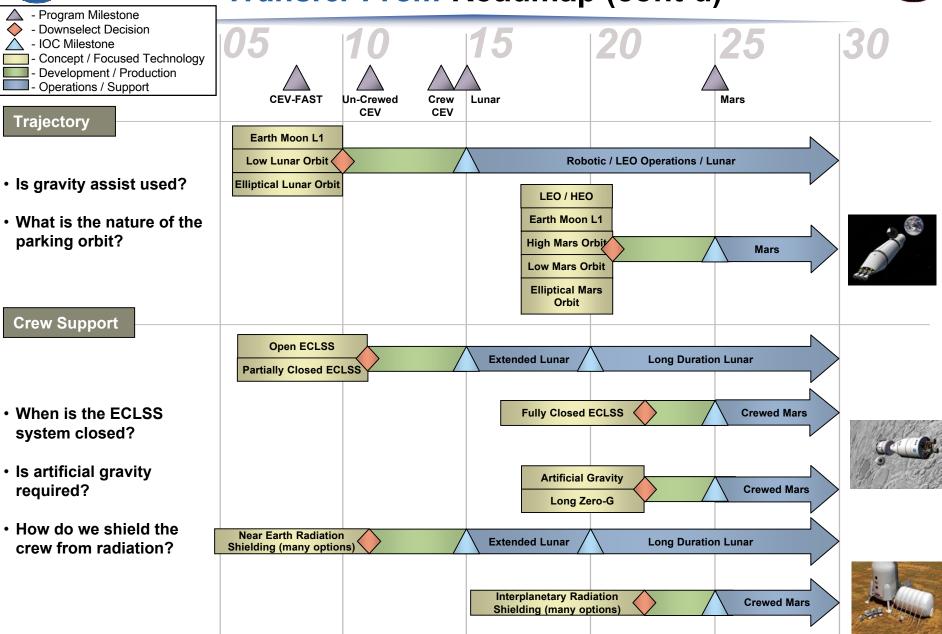


NASA

**Destination Orbital Operations and** 

Transfer From Roadmap (cont'd)

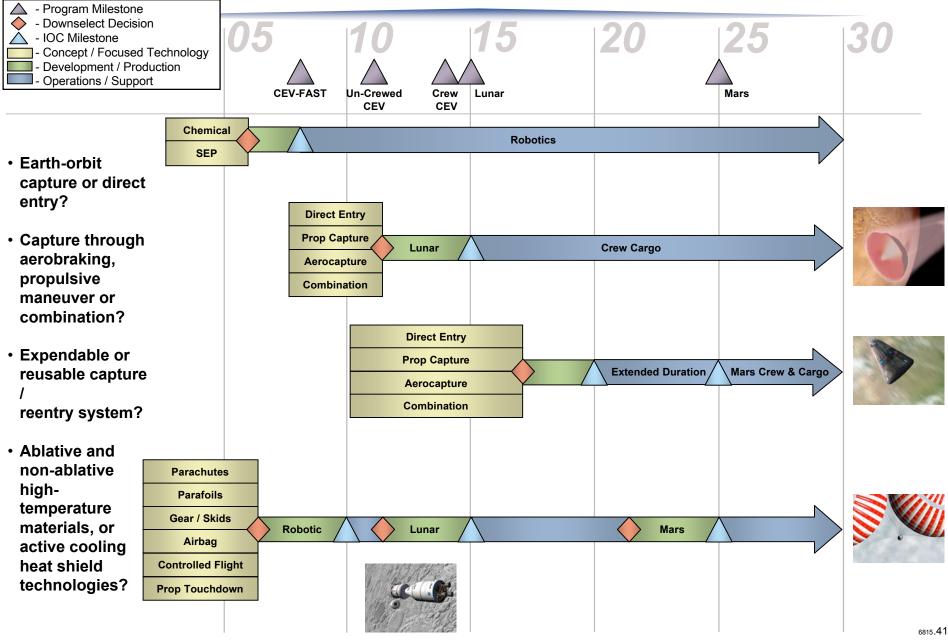






## Earth Capture / Reentry Roadmap









### **Space Transportation Needs Assessment**



#### Spiral 1

|  |                 |                 | , -                |  | ,                        | Key         | Transport            | tation Functions |         |              | S  |               |  |  |
|--|-----------------|-----------------|--------------------|--|--------------------------|-------------|----------------------|------------------|---------|--------------|--|---------------|--|--|
| Van Tananastatian Canability                               |                 | rth To Orbit    |                    | Earth Orbital  |                          | to Moon     | Moon                 | to Earth Return  |         | arth to Mars |  | to Earth Retu |  | lar System   |
| Key Transportation Capabilities<br>Transportation Elements | Robotic         | Human Cargo     | Robotic            | : Human Cargo  | Robotic                  | luman Cargo | Robotic              | Human Cargo      | Robotic | Human Cargo  | Robotic  | Human C       | argo   | Robotic  |
| ELV / EELV   |                 | 0               |                    |  |                          |             |                      |                  |         |              |  |               | - 2  |  |
| EELV Derived   | o               | ö               |                    |  |                          |             | -                    |                  | -       |              | -  |               |  |  |
| Shuttle Derived  | o               | ö               |                    |  |                          |             |                      |                  | -       |              |  |               |  |  |
| Crew Exploration Vehicle                                   | -               | X               |                    | 200 X 50.0   |                          |             |                      |                  | -       |              |  |               |  |  |
| Launch Escape System                                       | _               | x               |                    | A  |                          |             | -                    |                  |         |              |  |               |  |  |
| Upper Stage / Transfer Stage                               | _               | A COL           | X                  | X  | DOM: NO.                 |             | 9 X                  |                  | X       |              | X  |               | The state of   | 10 Y 10 10 10  |
| In-Space Propellant / Supply Depot                         | 1               |                 | Charles a state of | 100000000000000000000000000000000000000  | STATE A DESIGNATION OF   |             | Contract of the last |                  |         |              | A STATE OF THE PARTY OF  |               | Electric Section 1   | 10 3 Mg  |
| Planetary Capture / Entry                                  | 1               |                 |                    |  | SEEX SEE                 |             |                      |                  | X       |              |  |               | 100000   | A X  |
| Planetary Landing  | 1               |                 |                    |  |                          |             |                      |                  | X       |              |  |               | 10000  |  |
| Surface Mobility   |                 |                 |                    |  | 0                        |             | 0                    |                  | x       |              | 0  |               |  |  |
| Planetary Ascent   |                 |                 |                    |  |                          |             | X X                  |                  |         |              | X  |               | 1000000  | The state of the s |
| Reentry at Earth   |                 |                 | 1000 Years         | THE PERSON NAMED IN  |                          |             |                      |                  |         |              |  |               | - 1000   |  |
| Propulsion Systems   |                 |                 |                    | THE RESERVE TO SERVE  |                          |             |                      |                  |         |              |  |               |  |  |
| Chemical   |                 |                 |                    |  |                          |             |                      | 2 (0.00)         |         |              |  |               |  |  |
| Liquid   |                 | - 11            |                    |  |                          |             |                      |                  |         |              |  |               |  |  |
| Cryogenics   | HINGX SOCI      | X               | 0                  | 0  | 0                        |             | 0                    |                  | 0       |              | 0  |               | 10000  | 0  |
| Storables  | X               |                 | No.                | X  | ŏ                        |             | ŏ                    |                  | ŏ       |              | ŏ  |               |  | ŏ  |
| Solid / Hybrid   | ×               | 0               |                    |  | ŏ                        |             | ŏ                    |                  | ŏ       |              | ŏ  |               | 100  | ŏ  |
| Launch Assist  | Ô               | ő               |                    |  |                          |             |                      |                  |         |              |  |               |  | and the same of  |
| Nuclear Thermai  |                 |                 |                    |  |                          |             |                      |                  |         |              |  |               |  |  |
| Electric   |                 |                 |                    |  |                          |             |                      |                  |         |              |  |               |  |  |
| Low Power (<50kw)  |                 |                 | 0                  |  | 0                        |             | 0                    |                  | 0       |              | 0  |               | The same of  | and the same   |
| Medium Power (50-500kw)                                    |                 |                 |                    |  | ŏ                        |             | ŏ                    |                  | ŏ       |              | ő  |               | District of the last of the la |  |
| High Power (>500kw)  |                 |                 |                    |  |                          |             |                      |                  | -       |              |  |               |  |  |
| Propellantless   |                 |                 |                    | -  |                          |             |                      |                  |         |              |  |               |  |  |
| Aeroassist (Capture / Entry)                               |                 |                 | 0                  | NOSX COST  |                          |             | 0                    |                  | 0       |              | 0  |               |  | 0  |
| Sails  |                 |                 |                    |  |                          |             |                      |                  |         |              |  |               | 1000   | ő  |
| Tethers  |                 |                 |                    |  |                          |             |                      |                  |         |              |  |               |  |  |
| Vehicle Systems  |                 |                 |                    |  |                          | 14.0        |                      |                  |         |              |  |               |  |  |
| Lightweight Structures                                     | 0               | 0               | 0                  |  | 0                        |             | X                    |                  | X       |              | 100 X  |               | 10000  | X  |
| Deployable Systems   |                 |                 | 0                  |  | 0                        | E021        |                      |                  | X       |              | X  |               | 2000   | X  |
| Radiation Hardening / Shielding                            |                 |                 |                    | 0  | o                        |             | Ö                    |                  | Ö       |              | Ö  |               | 2000   | 0  |
| MMOD Protection  |                 |                 |                    | o l  |                          |             |                      |                  |         |              | The state of the s |               |  |  |
| Efficient Thermal Systems                                  |                 |                 |                    |  | 0                        |             | 0                    |                  | 0       |              | 0  |               |  | 0  |
| Avionics/Intelligent System Health Management              | 2500 (0.00)     | 100 X 0000      | STOCK SECTION      | THESE COSTS  | 1550 X 2504              |             | 1000 MIN             |                  | X       |              | No.  |               | -  |  |
| Power (generation, conversion, distribution)               | W 88            | x I             | X III              | X .  | x                        |             | Y                    |                  | x       |              | X  |               | 122500   | To the second  |
| Communications and Data Handling                           | ×               | x .             | x                  |  | x x                      |             | x                    |                  | x       |              | X  |               | 2000   | X  |
| Guidance, Navigation & Control                             |                 | x .             | Ŷ                  | X  |                          |             | Ŷ                    |                  | X       |              | - X  |               | 1 00000  |  |
| Reaction Control/Orbital Maneuvering                       | X               | X I             | ×                  | X  | No. X                    |             | X X                  |                  | X       |              | K Syllis   |               | 60000  | X  |
| Cryo Fluid Management                                      |                 |                 | o                  | 0  | 0                        |             | Ô                    |                  | Ô       |              | Ô  |               | 120,000  | - V. S   |
| Systems Engineering and Integration (inc. M&S)             | No. of the last | Inc. O X Street | X                  | X  | X                        |             | Ne yes               |                  | X       |              | CITY OF  |               | Reserve  | X  |
| Human Systems  | -               |                 | -                  |  |                          |             | ******               |                  |         |              |  |               |  |  |
| Life Support   |                 | X               |                    | X  |                          |             |                      |                  |         |              |  |               |  |  |
| Radiation Protection                                       |                 |                 |                    |  |                          |             |                      |                  |         |              |  |               | 30 II  |  |
| Biomedical Countermeasures                                 |                 |                 |                    |  |                          |             |                      |                  |         | C            |  |               | 12/11  |  |
| Crew Systems; In-space                                     |                 | X               |                    | 16 X 10 H  |                          |             |                      |                  |         |              |  |               |  |  |
| Crew Systems; Surface                                      |                 |                 |                    |  |                          |             |                      |                  |         |              |  |               |  |  |
| Artifical Gravity  |                 |                 |                    |  |                          |             |                      |                  |         |              |  |               |  |  |
| Operations   |                 |                 |                    |  |                          |             |                      |                  |         |              |  |               |  |  |
| Automated  |                 | 17              |                    |  |                          |             |                      |                  |         |              |  |               | - 1  |  |
| Rendezvous and Docking                                     |                 |                 | Y                  | 0  | 0                        |             | 0                    |                  | 0       |              | 0  | (4)           | -  | 0  |
| Manuevering  |                 |                 | Ý                  | ŏ  | 100                      |             | May and              |                  | ×       |              | X  |               | CHARGO   | ×  |
| Decision Making  |                 |                 | Ô                  |  | ò                        |             | ô                    |                  | ô       |              | ò  |               | TO THE   |  |
| On-Orbit Assembly and/or Repair (EVA)                      |                 |                 |                    | 0  |                          |             |                      |                  |         |              | -  |               |  |  |
| Launch and Payload Processing / Range                      | THAN X COLD     | ×               |                    |  |                          |             |                      |                  | -       |              |  |               |  |  |
| Recovery   |                 |                 | 0                  | X  |                          |             | 100 X 100            |                  |         |              | X  |               | The same   |  |
| ISRU Propellants/Fluids                                    |                 |                 |                    | A  |                          |             | ^                    |                  | -       |              | -  |               | -  | A CONTRACTOR OF THE PARTY OF TH |
| Propellant Transfer  |                 |                 |                    |  |                          |             |                      |                  | -       |              |  |               |  |  |
|  |                 | ALCOHOL: CORNEL |                    | Committee of the commit | Designative and the last |             | Towns County         |                  |         |              |  |               | -  |  |
| Communications and Navigation Network                      |                 |                 |                    |  |                          |             |                      |                  |         |              |  |               |  |  |





#### Difference Between Spiral 1 and 2

|  | 70 <u>10</u> | ulle To C | late. |         | Forth Only |       |         |        |       | Transport | ation Fur | nctions | FOUND TO   | Mara ta Ca   | dh Batura | Color Cont              |
|--|--------------|-----------|-------|---------|------------|-------|---------|--------|-------|-----------|-----------|---------|--|--|-----------|-------------------------|
| ey Transportation Capabilities                 |              | rth To Or |       |         | Earth Orbi |       |         | Human  |       |           | to Earth  |         | Earth to Mars<br>Robotic Human Carg  | Mars to Ear  |           | Solar Syster<br>Robotic |
| ransportation Capabilities                     | KODOUC       | numan     | Cargo | RODOLIC | numan      | Cargo | Robotic | riuman | Cargo | RODOUG    | numan     | Cargo   | Robotic Human Garg   | O RODOUC HUII  | ian Cargo | Robotic                 |
| ELV / EELV                                     |              | 0         | 0     |         | _          |       |         |        |       |           |           |         |  |  |           |                         |
| EELV Derived                                   | X<br>O       | 0         | 0     |         |            |       |         | _      |       |           |           |         |  |  |           |                         |
| Shuttle Derived                                | ŏ            | Ö         | 0     |         |            |       |         |        |       |           |           |         |  |  |           |                         |
| Crew Exploration Vehicle                       | U            |           | U     |         | X          |       |         | X      |       |           | X         |         |  |  |           |                         |
| Launch Escape System                           | _            | X         |       |         |            |       |         | ^      |       |           | ^         |         |  |  |           |                         |
|  |              | ^         |       | X       | X          |       |         | Х      | 0     |           | X         |         | X  | X  |           | X                       |
| Upper Stage / Transfer Stage                   |              |           |       | ^       | Α.         |       |         | ^      | 0     |           | ^         |         |  | A  |           | Α                       |
| In-Space Propellant / Supply Depot             | _            |           | _     |         |            |       |         | v      | 0     |           |           |         | X  |  |           |                         |
| Planetary Capture / Entry                      | _            |           |       |         |            |       |         | X      |       |           |           |         | STATE OF THE PARTY |  |           | X                       |
| Planetary Landing                              | _            |           |       |         |            |       |         | X      | 0     |           |           |         | X  | v  |           | Х                       |
| Surface Mobility                               | _            |           |       | _       | -          |       |         | 0      |       |           | v         |         | ^  | X  |           |                         |
| Planetary Ascent                               |              |           |       |         |            |       |         |        |       |           | X         |         |  | , A  |           |                         |
| Reentry at Earth                               |              |           |       | X       | N A        |       |         |        |       |           | X         |         |  | X I  | - 1       | Х                       |
| opulsion Systems                               |              |           |       |         |            |       |         |        |       |           |           |         |  |  |           |                         |
| Chemical                                       | _            |           |       |         |            |       |         |        |       |           |           |         |  | 2  |           |                         |
| Liquid   |              | -         |       |         |            |       |         |        |       |           | **        |         |  |  |           |                         |
| Cryogenics                                     | X            | X         | Х     | 0       | 0          | 0     |         | Х      | 0     |           | X         |         | 0  | 0  |           | 0                       |
| Storables                                      | X            |           |       | X       | X          | X     |         | 0      | 0     | 1 %       | X         |         | 0  | 0  |           | 0                       |
| Solid / Hybrid                                 | Х            | 0         | 0     |         |            |       |         |        |       |           |           |         | 0  | 0  |           | 0                       |
| Launch Assist                                  | 0            | 0         | 0     |         |            |       |         |        |       |           |           |         |  | 2  |           |                         |
| Nuclear Thermal                                |              |           |       |         |            |       |         |        |       |           |           |         |  | 5  |           |                         |
| Electric                                       |              |           |       |         |            |       |         |        |       |           |           |         | 100  |  |           |                         |
| Low Power (<50kw)                              |              |           |       | 0       | 5 15       | 0     |         |        |       |           |           |         | 0  | 0  |           | X                       |
| Medium Power (50-500kw)                        |              |           |       |         |            |       |         |        |       |           |           |         | 0  | 0  |           | X                       |
| High Power (>500kw)                            |              |           |       |         |            |       |         |        |       |           |           |         |  | 3  |           |                         |
| Propellantless                                 |              |           |       |         |            |       |         |        |       |           | 1000      |         |  | A CONTRACTOR OF THE PARTY OF TH |           | -                       |
| Aeroassist (Capture / Entry)                   |              |           |       | 0       | X          |       |         |        |       |           | X         |         | 0  | 0  |           | X                       |
| Sails  | 7            |           |       |         |            |       |         |        |       | 1 3       |           |         |  |  |           | X                       |
| Tethers  |              |           |       |         |            |       |         |        |       |           |           |         |  |  |           |                         |
| ehicle Systems                                 |              |           |       |         |            |       |         |        |       |           |           |         |  |  |           |                         |
| Lightweight Structures                         | 0            | 0         | 0     | 0       |            | 0     |         | 0      | 0     |           | 0         |         | 0  | X  |           | X                       |
| Deployable Systems                             |              |           | .445  | 0       |            | 0     |         | X      | 0     |           | X         |         | 0  | X  |           | X                       |
| Radiation Hardening / Shielding                |              |           |       |         | 0          |       |         | X      | 0     |           | X         |         | 0  | 0  |           | 0                       |
| MMOD Protection                                |              |           |       |         | 0          |       |         | X      | 0     |           |           |         |  |  |           |                         |
| Efficient Thermal Systems                      | 1            |           |       |         |            |       |         | X      | 0     |           | X         |         | 0  | 0  | -3        | 0                       |
| Avionics/Intelligent System Health Management  | X            |           | X     | Х       | X          | X     |         | X      | 0     |           | X         |         |  | X  |           | X                       |
| Power (generation, conversion, distribution)   | X            |           | Х     | Х       | X          | Х     |         | Х      | 0     |           | X         |         | X  | X  |           |                         |
| Communications and Data Handling               | X            | X         | X     | X       | X          | X     |         | X      | 0     |           | X         |         | ×  | X  |           | X                       |
| Guidance, Navigation & Control                 | X            | Х         | Х     | Х       | X          | Х     |         | Х      | 0     |           | Х         |         | X  | X  |           | X                       |
| Reaction Control/Orbital Maneuvering           | X            | X         | Х     | Х       | X          | Х     |         | X      | 0     | 7 1       | Х         |         | X S  | X  |           | X                       |
| Cryo Fluid Management                          |              |           |       | 0       | 0          | Х     |         | X      | 0     |           | X         |         | 0  | 0  |           |                         |
| Systems Engineering and Integration (inc. M&S) | X            | X         | X     | Х       | X          | X     |         | X      | X     |           | X         |         | X  | X  |           | X                       |
| uman Systems                                   |              |           | -     |         | -          | - "   |         | - "    |       |           |           |         |  |  |           |                         |
| Life Support                                   |              | X         |       |         | X          |       |         | Х      |       |           | X         |         |  |  |           |                         |
| Radiation Protection                           |              |           | 100   |         |            |       |         | X      |       |           | X         |         |  |  |           |                         |
| Biomedical Countermeasures                     |              |           |       |         |            |       |         |        |       |           | - Maria   |         |  |  |           |                         |
| Crew Systems; In-space                         |              | X         |       |         | X          |       |         | X      |       |           | х         |         |  |  |           |                         |
| Crew Systems; Surface                          |              |           |       |         |            |       |         | x      |       |           | - ^       |         |  |  |           |                         |
| Artifical Gravity                              |              |           |       |         |            |       |         | ^_     |       |           |           |         |  |  |           |                         |
| perations                                      |              |           |       |         |            |       |         |        |       |           |           |         |  |  |           |                         |
| Automated                                      |              |           |       |         |            |       |         |        |       |           |           |         |  |  |           |                         |
| Rendezvous and Docking                         |              |           |       | X       | X          | X     |         | 0      | 0     |           | X         |         | 0  | 0  |           | 0                       |
| Manuevering Manuevering                        |              |           |       | x       | x          | x     |         | X      | 0     |           | x         |         |  | X  |           | Ÿ                       |
| Decision Making                                |              |           |       | ô       | ^          | ô     |         | ô      | 0     |           | ô         |         | 0  | ô  |           | Ŷ                       |
| On-Orbit Assembly and/or Repair (EVA)          |              |           |       | U       | 0          | 0     | -       | 0      | 0     |           | 0         |         |  | U  |           | ^                       |
|  |              | v         | v     |         | U          | U     |         | 0      | 0     |           | U         |         |  |  |           |                         |
| Launch and Payload Processing / Range          | X            | X         | X     | - 0     |            |       |         |        |       |           | Y         |         |  | Y  |           | -                       |
| Recovery                                       |              |           |       | 0       | X          |       |         |        |       |           | X         |         |  | X .  |           |                         |
| ISRU Propellants/Fluids Propellant Transfer    |              |           |       |         |            | -     |         | -      |       |           |           |         |  |  |           |                         |
|  |              |           |       | 1       |            | 0     |         | 0      | 0     |           |           |         |  |  |           |                         |
| Communications and Navigation Network          | Y.           |           |       |         |            | X     | _       | X      | 0     |           | X         |         | Company of the Compan |  |           |                         |





Spiral 2

|  |  | rth To Ort   |         |                    | Earth Orbi   |             |         | arth to Mo  | on   |         | to Earth             | Return |  | irth to Mars |       |  | o Earth R |       | Solar System   |
|--|--|--|---------|--------------------|--------------|-------------|---------|---|--|---------|----------------------|--------|--|--------------|-------|--|-----------|-------|--|
| ey Transportation Capabilities                 | Robotic  | Human  | Cargo   | Robotic            | Human        | Cargo       | Robotic | Human   | Cargo  | Robotic | Human                | Cargo  | Robotic  | Human        | Cargo | Robotic                                      | Human     | Cargo | Robotic  |
| ransportation Elements                         |  |  |         |                    |              |             |         |   |  |         |                      |        |  |              |       |  |           |       |  |
| ELV / EELV                                     | X  | 0  | 0       |                    |              |             |         |   |  |         |                      |        |  |              | - iii |  |           |       |  |
| EELV Derived                                   | 0  | 0  | 0       |                    |              |             |         |   |  |         |                      |        |  |              |       |  |           |       |  |
| Shuttle Derived                                | 0  | 0  | 0       |                    |              |             |         |   |  |         |                      |        |  |              |       |  |           |       |  |
| Crew Exploration Vehicle                       |  | X  |         |                    | Mark Mark    |             |         | ×   |  |         | X                    |        |  |              |       |  |           |       |  |
| Launch Escape System                           |  | X  |         |                    |              |             |         |   |  |         |                      |        |  | - 1          |       |  |           | 8     |  |
| Upper Stage / Transfer Stage                   |  |  |         | X                  | TO X         |             |         | Street, Square  | 0  |         | TO XX                |        | X  |              |       | X  |           |       |  |
| In-Space Propellant / Supply Depot             |  |  |         |                    |              |             |         |   |  |         |                      |        |  |              |       |  |           |       |  |
| Planetary Capture / Entry                      |  |  |         |                    |              |             |         | X   | 0  |         |                      |        | X  |              |       |  |           |       | X  |
| Planetary Landing                              |  |  |         |                    |              |             |         | X   | 0  |         |                      |        | X  |              | - 1   |  |           |       | ENAME DE   |
| Surface Mobility                               |  |  |         |                    |              |             |         | 0   |  |         |                      |        | -X   |              |       | X  |           |       |  |
| Planetary Ascent                               |  |  |         |                    |              |             |         |   |  |         | 10 X-31              | 1      |  |              |       | X  |           | V 7   | X TO THE REAL PROPERTY.  |
| Reentry at Earth                               |  |  |         | To you             | Acres 6      |             |         |   |  |         | Y                    |        |  |              |       | X  |           |       | ×  |
| opulsion Systems                               |  |  |         |                    |              |             |         |   |  |         |                      |        |  |              |       |  |           |       |  |
| Chemical                                       |  |  |         |                    |              |             |         |   |  |         |                      |        |  |              |       |  |           |       |  |
| Liquid   |  |  |         | -                  |              |             |         |   |  |         |                      |        |  | - 1          |       |  |           |       |  |
| Cryogenics                                     | X  | and X and  | X       | 0                  | 0            | 0           |         | TATE RES  | 0  |         | To the last the last |        | 0  |              |       | 0  |           |       | 0  |
| Storables                                      | ×  | man A stable   |         | -                  | ×            | ×           |         | o   | Ö  |         | X                    |        | ö  |              |       | ö  |           |       | 0  |
|  | X  | 0  | 0       | X                  |              | The second  |         | 0   | V  |         | THE REAL PROPERTY.   |        | ö  |              |       | ö  |           | -     | ö  |
| Solid / Hybrid                                 |  |  |         | _                  | +            |             | 3       | -   |  |         |                      |        | 0  |              |       | 0  |           |       | U  |
| Launch Assist                                  | 0  | 0  | 0       |                    | +            | -           |         | -   |  |         | -                    |        |  |              |       |  |           |       |  |
| Nuclear Thermal                                |  |  |         | -                  | -            |             |         |   |  |         |                      |        |  |              |       |  |           |       |  |
| Electric                                       |  |  |         |                    |              |             |         |   |  |         |                      |        |  |              | - 1   |  |           |       |  |
| Low Power (<50kw)                              |  |  |         | 0                  |              | 0           |         |   |  |         |                      |        | 0  |              |       | 0  |           |       | X.   |
| Medium Power (50-500kw)                        |  |  |         |                    |              |             |         |   |  |         |                      |        | 0  |              |       | 0  |           |       | X  |
| High Power (>500kw)                            |  |  |         |                    |              |             |         |   |  | 4 = 4   |                      |        |  |              |       |  |           |       |  |
| Propellantless                                 |  |  |         |                    |              |             |         |   |  |         |                      |        |  |              |       |  |           |       |  |
| Aeroassist (Capture / Entry)                   |  |  |         | 0                  | X            |             |         |   |  |         | X                    |        | 0  |              |       | 0  |           |       |  |
| Sails  |  |  |         |                    |              |             |         |   |  |         |                      |        |  |              |       |  |           |       |  |
| Tethers  |  |  |         |                    |              |             |         |   |  |         |                      |        |  |              |       |  |           |       |  |
| ehicle Systems                                 |  |  |         |                    |              |             |         |   |  |         |                      |        |  |              |       |  |           |       |  |
| Lightweight Structures                         | 0  | 0  | 0       | 0                  |              | 0           |         | 0   | 0  | N = 1   | 0                    |        | 0  |              |       | X  |           | =_11  | X  |
| Deployable Systems                             |  |  |         | 0                  |              | 0           |         | X   | 0  |         | X                    |        | 0  |              |       | X  |           |       |  |
| Radiation Hardening / Shielding                |  |  |         |                    | 0            |             |         | THE REAL PROPERTY.  | 0  |         | X                    |        | 0  |              |       | 0  |           |       | 0  |
| MMOD Protection                                |  |  |         |                    | 0            |             |         |   | 0  |         | -                    |        |  |              |       |  |           |       |  |
| Efficient Thermal Systems                      |  |  |         |                    |              |             |         | X   | 0  |         | X                    |        | 0  |              |       | 0  |           |       | 0  |
| Avionics/Intelligent System Health Management  | - X  | mark X annual  | No. No. | X                  | X            | COST Y COST |         | X   | 0  |         | X                    |        |  |              | = 1   | X  |           |       |  |
| Power (generation, conversion, distribution)   | X X  | X  | ×       | X                  | ×            | X           |         | × ×   | 0  |         | X                    |        | PARTY AND REAL PROPERTY.   |              |       | X  |           |       |  |
| Communications and Data Handling               | ×  | X  | X       | X                  | X            | X           |         | ×   | o  |         | X                    |        | ×  |              |       | X  |           |       | ×  |
| Guidance, Navigation & Control                 | ×  | X  | ×       | X                  | X            | X           |         | ×   | o  |         | X                    |        | ×  |              |       | Ŷ.   |           |       |  |
| Reaction Control/Orbital Maneuvering           | x  | X  | Ŷ       | X                  |              | X           |         | x   | 0  |         | X                    |        |  |              |       |  |           |       | The state of the s |
| Cryo Fluid Management                          | And the last of th |  |         | Ô                  | 0            | X           |         | X   | o  |         | X                    |        | 0  |              |       | ô  |           |       |  |
| Systems Engineering and Integration (inc. M&S) | ×  | CONTRACTOR OF STREET   |         | X                  | ×            |             |         | 0   | No. of Concession, Name of Street, or other party of the Concession, Name of Street, or other pa |         |                      |        |  |              |       |  |           |       | The Assessment of the Assessme |
| iman Systems                                   | A COLOR  | ALL DAVISORS OF THE PARTY OF TH | -       | No. of Concession, | - CONTRACTOR | Maria Maria |         | multiple to   | No.  |         |                      |        | A  |              |       |  |           |       |  |
|  |  |  |         |                    |              |             |         |   |  |         |                      |        |  |              |       |  |           |       |  |
| Life Support                                   | _  | X  |         | -                  | X            |             |         | DECEMBER OF THE PERSON OF THE |  |         | X                    |        |  |              |       |  |           |       |  |
| Radiation Protection                           |  |  |         | -                  | -            |             |         |   |  |         | X                    |        |  |              |       |  |           |       |  |
| Biomedical Countermeasures                     |  |  |         | -                  |              |             |         | 7.7   |  |         |                      |        |  |              | 11/0  |  |           |       |  |
| Crew Systems; In-space                         |  | X  |         | -                  | X            |             |         |   |  |         | X                    |        |  |              | - 1   |  |           |       |  |
| Crew Systems; Surface                          |  |  |         | -                  |              |             |         | X   |  |         |                      | 100    |  |              | 100   |  |           |       |  |
| Artifical Gravity                              |  |  |         |                    |              |             |         |   |  |         |                      |        |  |              |       |  |           |       |  |
| perations                                      | _  |  |         | ,                  | _            | ,           |         |   |  |         | _                    |        | _  |              |       |  |           |       |  |
| Automated                                      |  |  |         |                    |              |             |         |   |  |         |                      | -14    |  |              |       |  |           |       |  |
| Rendezvous and Docking                         |  |  |         | X                  | X            | X           |         | 0   | 0  |         | V. X                 |        | 0  |              |       | 0  |           |       | 0  |
| Manuevering                                    |  |  |         | X                  | X            | X           |         | X   | 0  |         | X                    | 1      | X  |              |       | - X  |           |       | ×  |
| Decision Making                                |  |  |         | 0                  |              | 0           |         | 0   | 0  |         | 0                    | 4      | 0  |              |       | 0  |           | -     | X  |
| On-Orbit Assembly and/or Repair (EVA)          |  |  |         |                    | 40           | 0           |         | 0   | 0  |         | 0                    |        |  |              | 8 1   |  | - 0 -     |       |  |
| Launch and Payload Processing / Range          | - X  | 000 X 1752   | X       |                    |              |             |         |   |  |         |                      |        |  |              | 7     |  |           |       |  |
| Recovery                                       |  |  |         | 0                  | X            |             | 17      |   |  |         | X                    | 1 7    |  |              |       | X  | 17.19     | -     | X  |
| ISRU Propellants/Fluids                        |  |  |         |                    |              |             |         |   |  | -       |                      |        |  |              |       |  |           |       |  |
| Propellant Transfer                            |  |  |         |                    |              | 0           |         | 0   | 0  |         |                      |        |  |              |       |  |           |       |  |
| Communications and Navigation Network          | 10000-1000   |  | ¥       | 1000               | -            | Delta de    |         | CONTRACTOR OF THE PERSON NAMED IN   | Ö  |         | 1000 S A             |        | The same of the sa |              |       | SALES AND DESCRIPTION OF THE PERSON NAMED IN |           |       |  |
|  |  |  |         |                    |              |             |         |   |  |         |                      |        |  |              |       |  |           |       |  |





#### Difference Between Spiral 2 and 3

|   |         | rth To O | rbit  |         | Earth Orb | ital  | -       | rth to Mo | Key   | Transport | to Earth | Poturo | _          | rth to Mar |       | Marc    | to Earth | Poturo | Color Custo             |
|---|---------|----------|-------|---------|-----------|-------|---------|-----------|-------|-----------|----------|--------|------------|------------|-------|---------|----------|--------|-------------------------|
| (au Tanana datina Canabilitia                             |         |          |       |         |           |       |         |           |       |           |          |        |            |            |       |         |          |        | Solar System<br>Robotic |
| Key Transportation Capabilities                           | Robotic | Human    | Cargo | Robotic | Human     | Cargo | Robotic | Human     | Cargo | Robotic   | Human    | Cargo  | Robotic    | Human      | Cargo | Kobotic | Human    | Cargo  | Robotic                 |
| ransportation Elements                                    |         |          |       |         |           |       |         | _         |       |           |          |        |            |            | -     |         | _        |        |                         |
| ELV / EELV  | X       | 0        | 0     |         | -         | _     |         |           |       |           |          |        |            |            |       |         |          |        |                         |
| EELV Derived  | 0       | 0        | 0     | _       |           |       |         |           |       |           |          |        |            |            | - 1   |         |          |        |                         |
| Shuttle Derived   | 0       | 0        | 0     |         | -         |       |         |           |       |           |          |        |            |            |       |         |          |        |                         |
| Crew Exploration Vehicle                                  |         | X        |       |         | X         |       |         | X         |       |           | X        |        |            |            |       |         |          |        |                         |
| Launch Escape System                                      |         | X        |       |         |           |       |         |           |       |           |          |        |            |            |       | -       |          |        | - 15                    |
| Upper Stage / Transfer Stage                              |         |          |       | X       | X         |       |         | X         | Х     |           | X        | 0      | X          |            |       | X       |          |        | X                       |
| In-Space Propellant / Supply Depot                        |         |          |       |         |           | 0     |         |           | 0     |           |          | 0      |            |            |       |         |          |        |                         |
| Planetary Capture / Entry                                 |         |          |       |         |           |       |         | X         | Х     |           |          |        | X          |            |       |         |          |        | X                       |
| Planetary Landing   |         |          |       |         |           |       |         |           | X     |           |          |        | X          |            |       |         |          |        |                         |
| Surface Mobility  |         |          |       |         |           |       |         | X         | Х     |           |          |        | X          |            |       |         |          |        |                         |
| Planetary Ascent  |         |          |       |         |           |       |         | -         | - 10  |           |          |        | -          |            |       | X       |          |        |                         |
| Reentry at Earth  |         |          |       | X       | X         |       |         |           |       |           | X        |        | 1          |            |       | X       |          |        | X                       |
| Propulsion Systems  |         |          |       |         |           |       |         |           |       |           |          |        |            |            |       |         |          |        |                         |
| Chemical  |         |          |       |         |           |       |         |           |       |           |          |        |            | 1          | - 1   |         |          | 120    |                         |
| Liquid  |         |          |       |         |           |       |         |           |       |           |          |        |            |            |       |         |          |        |                         |
| Cryogenics  | X       | X        | Y     | 0       | 0         | 0     |         | Y         | Х     |           | X        |        | 0          |            | 7     | 0       |          |        | 0                       |
| Storables   | x       | ^        | ^     | ×       | ×         | x     |         | ô         | ô     | _         | x        |        | ŏ          |            |       | ŏ       |          |        | ŏ                       |
|   | X       | 0        | 0     | _^      | _ ^       | ^_    |         | U         | U     |           | _ ^ _    |        | Ö          |            |       | 0       |          |        | 0 0                     |
| Solid / Hybrid  |         |          |       |         | -         | -     |         |           |       |           |          |        | U          |            |       | U       |          |        | 0                       |
| Launch Assist   | 0       | 0        | 0     |         |           |       |         |           |       |           |          |        |            |            |       |         |          |        |                         |
| Nuclear Thermal   |         |          |       |         |           |       |         |           | 0     |           |          |        |            |            |       |         |          |        |                         |
| Electric  |         |          |       |         |           |       |         |           |       |           |          |        |            |            |       |         |          |        |                         |
| Low Power (<50kw)   |         |          |       | 0       | 3 0       | 0     |         |           | 0     | ( 1       |          | 0      | 0          |            | - 7   | 0       |          |        | ×                       |
| Medium Power (50-500kw)                                   |         |          |       |         |           |       |         |           | 0     | 1         |          | 0      | 0          |            |       | 0       |          |        |                         |
| High Power (>500kw)                                       |         |          |       |         |           |       |         |           |       |           |          |        | A STATE OF |            | 7     |         |          |        |                         |
| Propellantless  |         |          |       |         |           |       |         |           |       |           |          |        |            |            |       |         |          |        |                         |
| Aeroassist (Capture / Entry)                              |         |          |       | 0       | X         |       | 1.      |           |       |           | X        |        | 0          |            |       | 0       |          |        | X                       |
| Sails   |         |          |       |         |           |       |         |           |       |           |          |        |            |            |       |         |          |        | X                       |
| Tethers   |         |          |       |         |           |       |         |           | 0     |           |          |        |            |            |       |         |          |        |                         |
| ehicle Systems  |         |          |       |         |           |       |         |           |       |           |          |        |            |            |       |         |          |        |                         |
| Lightweight Structures                                    | 0       | 0        | 0     | 0       |           | 0     |         | 0         | Х     |           | 0        | 0      | 0          |            |       | Х       |          |        | Y .                     |
| Deployable Systems  | _       |          | -     | ŏ       |           | 0     |         | X         | x     |           | X        | o      | ŏ          |            |       | Ŷ       |          |        | - 0                     |
| Radiation Hardening / Shielding                           |         |          |       | -       | 0         |       |         |           | x     |           |          | ő      | ő          | -          | _     | ô       |          |        | ô                       |
| MMOD Protection   |         |          | _     | -       | 0         |       |         | X         |       |           | X        |        | U          |            | -     | U       | _        |        | U                       |
|   |         |          | -     | _       | U         |       |         | Х         | X     |           |          | 0      |            | -          |       |         |          | _      |                         |
| Efficient Thermal Systems                                 |         |          |       |         |           | -     | 1.0     | X         | Х     | 5         | X        | 0      | 0          |            | - 2   | 0       |          |        | 0                       |
| Avionics/Intelligent System Health Management             | X       | Х        | X     | Х       | X         | X     |         | X         | Х     |           | X        | 0      |            |            |       | Х       |          |        | X                       |
| Power (generation, conversion, distribution)              | X       | Х        | X     | X       | X         | X     |         | X         | Х     |           | X        | 0      | X          |            |       | X       |          |        | X                       |
| Communications and Data Handling                          | X       | X        | X     | X       | X         | X     |         | X         | Х     | 5         | X        | 0      | X          |            |       | X       |          |        | X                       |
| Guidance, Navigation & Control                            | X       | X        | X     | X       | X         | X     |         | Х         | X     |           | X        | 0      | X          |            |       | X       |          |        | X                       |
| Reaction Control/Orbital Maneuvering                      | X       |          | X     | X       | X         | X     |         |           | Х     |           |          | 0      | X          |            |       |         |          |        |                         |
| Cryo Fluid Management                                     |         |          |       | 0       | 0         | X     |         | X         | Х     | J. O.     | X        | 0      | 0          |            | į.    | 0       |          |        | 1971                    |
| Systems Engineering and Integration (inc. M&S)            | X       |          | X     | X       | X         | X     |         | X         | X     |           | X        | 0      | X          |            | - 1   | X       |          |        |                         |
| uman Systems  |         |          |       |         |           |       |         |           |       |           |          |        |            |            |       |         |          |        |                         |
| Life Support  |         | X        |       |         | X         |       |         | X         |       | 1         | Х        |        |            |            |       |         |          |        |                         |
| Radiation Protection                                      |         |          |       |         |           |       |         | X         |       | 3         | X        |        |            |            |       |         |          |        |                         |
| Biomedical Countermeasures                                | _       |          |       |         | 1         |       |         |           |       |           | -        |        |            |            |       |         |          |        |                         |
| Crew Systems; In-space                                    |         | X        |       |         | X         |       |         | X         |       |           | X        |        |            |            |       |         |          |        |                         |
|   |         | ^        |       |         | ^         |       |         | ×         |       |           | ^        |        |            |            |       |         |          |        |                         |
| Crew Systems; Surface                                     |         |          |       |         | -         |       |         | Α         |       |           |          |        | -          |            |       |         |          |        |                         |
| Artifical Gravity   |         |          |       |         |           |       |         |           |       |           |          |        |            |            |       |         |          |        |                         |
| perations   |         |          | _     | 1       |           | _     |         |           |       |           |          |        |            |            |       |         |          |        |                         |
| Automated   |         |          |       |         |           |       |         |           |       |           |          |        |            |            | - 1   |         |          |        |                         |
| Rendezvous and Docking                                    |         |          |       | X       | X         | X     |         | 0         | 0     |           | X        | 0      | 0          |            |       | 0       |          |        | 0                       |
| Manuevering   | 1       |          |       | X       | X         | X     |         | X         | Х     | ( H       | X        | 0      | X          |            |       | X       |          |        | X                       |
| Decision Making   |         |          |       | 0       |           | 0     |         | 0         | Х     |           | 0        | 0      | 0          |            |       | 0       |          |        | X                       |
| On-Orbit Assembly and/or Repair (EVA)                     |         |          |       |         | 0         | 0     |         | 0         | Х     | § 1       | X        |        |            |            | 1     |         |          |        |                         |
| Launch and Payload Processing / Range                     | X       | X        | X     |         |           |       |         |           |       |           |          |        |            |            |       |         | 1        |        |                         |
| Recovery  |         |          |       | 0       | X         |       |         |           |       |           | X        |        |            |            |       | Х       |          |        | X                       |
| ISRU Propellants/Fluids                                   |         |          |       |         |           |       |         | 0         |       |           | 0        |        |            |            | 10    |         |          |        |                         |
|   |         |          |       |         | _         |       |         |           |       |           | -        |        |            |            |       |         |          | 4      |                         |
|   |         |          |       |         | 0         | 0     |         | 0         | Y     |           |          | 0      |            |            |       |         |          |        |                         |
| Propellant Transfer Communications and Navigation Network |         | V        | V     | 0       | 0         | Ô     |         | O<br>X    | X     |           | X        | 0      |            |            |       |         |          |        |                         |





#### Spiral 3

|  | E  | rth To O  | rbit            |                     | Earth Orbi        | tal           | Earth     | to Mo |           | ransport | to Earth  |  | Fo         | rth to Mars |       | Mare t   | o Earth R | eture | Solar Syste  |
|--|--|---|-----------------|---------------------|-------------------|---------------|-----------|-------|-----------|----------|-----------|--|------------|-------------|-------|----------|-----------|-------|--|
| ey Transportation Capabilities                 |  |   |                 |                     |                   |               | Robotic H |       |           |          |           |  |            |             | araa. |          |           |       | Robotic  |
| ransportation Capabilities                     | Robouc   | numan   | Cargo           | Roboac              | Human             | Cargo         | RODOUC F  | luman | Cargo     | RODOBC   | numan     | Cargo  | RODOUC     | Human C     | argo  | RODOUC   | numan     | Cargo | Robotic  |
| ELV / EELV                                     | V X  | 0   | 0               |                     |                   |               | -         |       |           |          |           |  |            |             |       |          |           |       |  |
| EELV Derived                                   | ô  | ö   | ö               |                     | +                 | -             |           |       |           |          |           |  |            |             |       |          |           |       |  |
|  | ŏ  | ö   | 0               |                     | -                 | -             |           |       |           |          |           |  |            |             |       | _        |           |       |  |
| Shuttle Derived                                | 0  |   |                 |                     | The second second |               |           | 100   |           |          | X         |  | _          |             |       | _        |           |       |  |
| Crew Exploration Vehicle                       | _  | X   |                 | -                   | X                 |               | -         | X     |           |          | Link Arms |  |            |             | -     | _        |           |       |  |
| Launch Escape System                           |  | X   |                 |                     |                   |               |           |       |           |          | -         |  |            |             |       |          |           |       | Company of the Company   |
| Upper Stage / Transfer Stage                   |  |   | -               | STATE OF THE PARTY. | X                 |               | 200       | X     | X         |          | X         | 0  | X          |             |       | X        |           |       | X  |
| In-Space Propellant / Supply Depot             |  |   |                 |                     | -                 | 0             |           |       | 0         |          |           | 0  |            |             |       |          |           |       | THE RESERVE TO SERVE THE   |
| Planetary Capture / Entry                      | _  |   | -               | -                   |                   |               |           | X     | X         |          |           |  | X          |             |       |          |           |       | X  |
| Planetary Landing                              |  |   |                 | -                   |                   |               |           | X     | X         |          |           |  | X          |             |       |          |           |       | X  |
| Surface Mobility                               |  |   |                 |                     |                   |               |           | X     | X         |          |           |  | X          |             |       | X        |           |       |  |
| Planetary Ascent                               |  |   |                 |                     |                   |               |           |       |           |          | X         |  |            | -11         |       | X        |           |       | X X  |
| Reentry at Earth                               |  |   |                 | X                   | * X               |               |           |       |           |          | X         |  |            |             |       | X        |           |       | ×  |
| opulsion Systems                               |  |   |                 |                     |                   |               |           |       |           |          |           |  |            |             |       |          |           |       |  |
| Chemical                                       |  |   |                 |                     |                   |               |           |       |           |          |           |  |            |             |       |          |           |       |  |
| Liquid   |  |   |                 |                     |                   |               |           |       |           |          |           |  |            |             | 1.77  |          |           |       |  |
| Cryogenics                                     | Hara X coul  | X   | Ci X            | 0                   | 0                 | 0             | 100       | X     | ×         |          | X         |  | 0          | 7 7         |       | 0        |           |       | 0  |
| Storables                                      | X  |   |                 | X                   | X                 | ×             |           | 0     | 0         |          |           |  | 0          |             |       | 0        |           |       | 0  |
| Solid / Hybrid                                 | X  | - 0   | 0               |                     |                   |               |           |       |           |          |           |  | 0          |             | - 5   | 0        |           |       | 0  |
| Launch Assist                                  | 0  | 0   | 0               |                     |                   |               |           |       |           |          |           |  |            |             |       |          |           |       | -  |
| Nuclear Thermal                                |  |   |                 | 1                   |                   |               |           |       | 0         | 1 1 1 1  |           |  |            |             |       |          |           |       |  |
| Electric                                       |  |   |                 |                     |                   |               |           |       |           |          |           |  |            |             |       |          |           | 14-   |  |
| Low Power (<50kw)                              |  |   |                 | 0                   |                   | 0             |           |       | 0         |          |           | 0  | 0          |             |       | 0        |           |       | E  |
| Medium Power (50-500kw)                        | _  |   |                 | -                   |                   | -             |           |       | ŏ         |          |           | ŏ  | ŏ          |             |       | ŏ        |           |       |  |
| High Power (>500kw)                            |  |   | -               | -                   | +                 | -             |           |       |           |          |           | - V  |            |             |       | -        |           |       | A STATE OF THE PARTY.  |
|  | _  |   | -               | -                   | -                 | -             |           |       |           |          |           |  |            |             |       | _        |           |       |  |
| Propellantless                                 |  |   |                 |                     |                   |               |           |       |           |          |           |  |            |             |       |          | -         |       |  |
| Aeroassist (Capture / Entry)                   |  |   |                 | 0                   | X                 |               |           |       |           |          | X         |  | 0          | 3.555       |       | 0        |           |       | POST X 100   |
| Sails  |  |   |                 | -                   |                   |               |           |       |           |          |           |  |            |             |       |          |           |       | X  |
| Tethers  |  |   |                 |                     |                   |               |           |       | 0         |          |           |  |            |             | _ = 5 |          |           |       |  |
| hicle Systems                                  |  |   |                 |                     |                   |               |           |       |           |          |           |  |            |             |       |          |           |       |  |
| Lightweight Structures                         | 0  | 0   | 0               | 0                   |                   | 0             |           | 0     | X         |          | 0         | 0  | 0          |             |       | X        |           |       | X  |
| Deployable Systems                             |  |   |                 | 0                   |                   | 0             | 100       |       | X         |          |           | 0  | 0          |             |       | X        |           |       |  |
| Radiation Hardening / Shielding                |  |   |                 |                     | 0                 |               |           |       | X         |          |           | 0  | 0          |             |       | 0        |           |       | 0  |
| MMOD Protection                                |  |   |                 |                     | 0                 |               |           | X     | X         |          |           | 0  |            |             |       |          |           |       |  |
| Efficient Thermal Systems                      |  |   |                 |                     |                   |               |           | X     | X         |          | To Xun )  | 0  | 0          |             |       | 0        |           |       | 0  |
| Avionics/Intelligent System Health Management  | X  | X   | X               | No.                 | X                 | X             | 100       | X     | X         |          | X         | 0  |            |             |       | X        |           | W = 1 | X  |
| Power (generation, conversion, distribution)   | X  | X   | X               | X                   | X                 | X             |           | X     | X         |          | X         | 0  | X          |             |       | X        |           |       | X  |
| Communications and Data Handling               | 250 4 0 0  | No.   | ×               | X                   | X                 | X             |           | ×     | X         |          | X         | 0  | X          |             |       | X        |           |       | X  |
| Guidance, Navigation & Control                 | THE NAME OF THE OWNER, | - X   |                 | X                   | X                 | X             |           |       | X         |          | X         | 0  | X          |             |       | ×        |           |       | The second second  |
| Reaction Control/Orbital Maneuvering           | 000 X 445  | X   | 0.0001          | No.                 | The same          | X             | 0         | X     | X         |          | X         | o  |            |             |       | 2        |           |       |  |
| Cryo Fluid Management                          | 100000   | Maria de la constantina della |                 | Ö                   | 0                 | X             |           | X     | X         |          | X         | 0  | O          | 100         |       | o        |           |       |  |
|  | X  | X   | Anna Xana       | X                   | a management      |               |           | 2     | Ŷ         |          | Ŷ         | ŏ  | 100 Y 100  |             |       | - X 5000 |           |       | X  |
| Systems Engineering and Integration (inc. M&S) | Α  | · · · ·   | Section Section | 1000                |                   | Black All St. | 000       | 300   | A         |          | A         | U  | No. of the |             |       | A        |           |       | A STATE OF THE PARTY OF THE PAR |
| ıman Systems                                   |  |   |                 |                     |                   |               |           |       |           |          |           |  |            |             |       |          |           |       |  |
| Life Support                                   |  | X   |                 | -                   | X                 |               | 200       | X     |           |          | X         |  |            |             |       |          |           |       |  |
| Radiation Protection                           |  |   |                 | -                   |                   | -             |           | X     |           |          | X         |  |            |             |       |          |           |       |  |
| Biomedical Countermeasures                     |  |   |                 | -                   |                   |               |           |       |           |          |           |  |            |             |       |          |           |       |  |
| Crew Systems; In-space                         |  | X   |                 |                     | X                 |               |           | X     |           |          | X         |  |            |             | - 1   |          |           |       |  |
| Crew Systems; Surface                          |  |   |                 |                     |                   |               | 28        | ) X   |           |          |           |  |            |             |       |          |           |       |  |
| Artifical Gravity                              |  |   |                 |                     |                   |               | 1 m       |       |           |          |           |  |            |             |       |          |           | 3     |  |
| perations                                      |  |   |                 |                     |                   |               |           |       |           |          |           |  |            |             |       |          | تنجمه     |       |  |
| Automated                                      |  |   |                 |                     |                   |               |           |       |           | 7. E. S  |           |  |            |             |       |          |           |       |  |
| Rendezvous and Docking                         |  |   |                 | X                   | A X               | X X           |           | 0     | 0         |          | X         | 0  | 0          |             |       | 0        |           |       | 0  |
| Manuevering                                    |  |   |                 | X                   | X                 | X             |           | X     | N. Carlot |          | ×         | 0  | X          |             |       | X        |           |       | ×  |
| Decision Making                                |  |   |                 | Ô                   | 1                 | Ö             |           | ô     | x         |          | Ô         | ŏ  | o          |             |       | Ö        |           |       | X  |
| On-Orbit Assembly and/or Repair (EVA)          |  |   |                 | The second second   | 0                 | o             |           | ö     | X         |          |           | THE RESERVE OF THE PARTY OF THE |            |             |       |          |           |       |  |
| Launch and Payload Processing / Range          | III X III  | X   | The Marie       |                     |                   | -             | -         | U     | ^         |          | _ ^       |  |            |             |       | _        |           |       |  |
|  | Harry Av. and  | -   | A               |                     | Total Control     |               |           |       |           |          | CONT.     |  |            |             |       |          |           |       |  |
| Recovery                                       |  |   |                 | 0                   | X                 |               |           |       |           |          | N. Alter  |  |            |             |       | X        |           |       | Market Mark  |
| ISRU Propellants/Fluids                        |  |   |                 |                     |                   |               |           | 0     |           |          | 0         |  |            |             |       |          |           |       |  |
| Propellant Transfer                            |  |   |                 | 0                   | 0                 | 0             |           | 0     | 7 14      |          |           | 0  |            |             | - 1   |          |           |       |  |
| Communications and Navigation Network          | X  |   |                 |                     | X                 |               |           |       |           |          | X         |  | 1000       |             |       |          |           |       |  |





#### Difference Between Spiral 3 and 4/5

| y Transportation Capabilities supportation Elements ELV / EELV EELV Derived Shuttle Derived Crew Exploration Vehicle Launch Escape System Upper Stage / Transfer Stage |              | Human | Cargo |     | Earth Orbi |     | Robotic | th to Mo<br>Human |    |          | to Earth I<br>Human |   | Robotic | rth to Ma |        |     | to Earth F<br>Human |     | Solar System<br>Robotic |
|--|--------------|-------|-------|-----|------------|-----|---------|-------------------|----|----------|---------------------|---|---------|-----------|--------|-----|---------------------|-----|-------------------------|
| ELV / EELV EELV Derived Shuttle Derived Crew Exploration Vehicle Launch Escape System Upper Stage / Transfer Stage   |              |       |       |     |            |     |         |                   |    |          |                     |   |         |           |        |     |                     |     |                         |
| ELV / EELV EELV Derived Shuttle Derived Crew Exploration Vehicle Launch Escape System Upper Stage / Transfer Stage   |              |       |       |     |            |     |         |                   |    |          |                     |   |         |           |        |     |                     |     |                         |
| EELV Derived Shuttle Derived Crew Exploration Vehicle Launch Escape System Upper Stage / Transfer Stage  |              |       | 0     |     |            |     |         |                   |    | i i      |                     |   |         |           |        |     |                     |     |                         |
| Shuttle Derived<br>Crew Exploration Vehicle<br>Launch Escape System<br>Upper Stage / Transfer Stage  |              | 0     | 0     |     |            |     |         |                   |    |          |                     |   |         |           |        |     |                     |     |                         |
| Crew Exploration Vehicle<br>Launch Escape System<br>Upper Stage / Transfer Stage   |              | 0     | 0     |     |            |     |         |                   |    |          |                     |   |         |           |        |     |                     |     |                         |
| Launch Escape System Upper Stage / Transfer Stage  |              | X     |       |     | Х          |     |         | X                 |    |          | X                   |   |         | X         |        |     | X                   |     |                         |
| Upper Stage / Transfer Stage   |              | x     |       |     |            |     |         |                   |    |          |                     |   |         |           |        |     |                     |     |                         |
|  |              |       |       | X   | X          |     |         | X                 | ¥  |          | X                   | 0 | X       | X         | 0      | X   | Х                   | 0   | X                       |
| In-Space Propellant / Supply Depot   |              |       |       |     |            | 0   |         |                   | ô  |          |                     | o |         | ô         | ō      | - ~ | ô                   | 0   |                         |
| Planetary Capture / Entry  |              |       |       | _   | -          |     |         | Α.                | ¥  |          |                     |   | y.      | X         | 0      |     |                     | -   | Y.                      |
| Planetary Landing  |              |       |       |     | _          |     |         | x                 | x  |          |                     |   | x       | x         | 0      |     |                     |     | - Ç                     |
| Surface Mobility   | _            |       |       |     | 1          |     |         | x                 | x  |          |                     |   | x       | x         | 0      | X   |                     |     |                         |
| Planetary Ascent   | _            |       |       | -   | 1          |     | -       |                   | _^ |          | X                   |   | _ ^     | _^        | 0      | x   | Х                   |     | Y                       |
|  |              |       |       | v   |            |     |         |                   |    |          | 0                   |   |         |           |        | -   | x                   |     | - 0                     |
| Reentry at Earth   |              |       |       |     | A          |     | 11      |                   |    |          |                     |   |         |           | - 4    |     | ٨                   |     | ^                       |
| opulsion Systems   | _            |       | _     |     |            |     |         | _                 |    | _        |                     |   |         |           | _      |     |                     |     |                         |
| Chemical   | _            |       |       | _   |            |     |         |                   |    |          |                     |   | 2 2     |           |        |     |                     |     |                         |
| Liquid   |              | -     |       |     |            |     |         |                   |    |          |                     |   | -       |           |        |     |                     |     |                         |
| Cryogenics   | X            | X     | X     | 0   | 0          | 0   |         | X                 | X  |          | X                   |   | 0       | X         | 0      | 0   | Х                   |     | 0                       |
| Storables  | X            |       |       | X   | X          | X   |         | 0                 | 0  | 1        | X                   |   | 0       | 0         | 0      | 0   | Х                   |     | 0                       |
| Solid / Hybrid   | X            | 0     | 0     |     |            |     |         |                   |    |          |                     |   | 0       |           |        | 0   |                     |     | 0                       |
| Launch Assist  | 0            | 0     | 0     |     |            |     |         |                   |    |          |                     |   | 2       |           |        |     |                     |     |                         |
| Nuclear Thermal  |              |       |       |     |            |     |         |                   | 0  |          |                     |   |         | 0         | 0      |     | 0                   | 0   | 0                       |
| Electric   |              |       |       |     |            |     |         |                   |    | 1 1      |                     |   |         |           |        |     |                     |     |                         |
| Low Power (<50kw)  |              |       |       | 0   | 1 1        | 0   |         |                   | 0  |          |                     | 0 | 0       |           | -      | 0   | (4)                 |     | ×                       |
| Medium Power (50-500kw)  |              |       |       |     |            |     |         |                   | 0  |          |                     | 0 | 0       |           | 0      | 0   |                     | 0   | X                       |
| High Power (>500kw)  |              |       |       |     |            |     | 100     |                   |    |          |                     |   | -       | 0         | 0      |     | 0                   | 0   |                         |
| Propellantless   |              |       |       |     |            |     |         |                   |    |          |                     |   |         |           |        |     |                     |     |                         |
| Aeroassist (Capture / Entry)   |              |       |       | 0   | X          |     |         |                   |    |          | X                   |   | 0       | 0         | X      | 0   | Х                   |     | X                       |
| Sails  | _            |       |       |     | - 0        |     |         |                   |    |          |                     |   |         | _         | ô      | _   | ^                   |     | Ŷ                       |
| Tethers  | _            |       | _     | _   | 1          |     |         |                   | 0  |          |                     |   |         |           | 0      |     |                     |     |                         |
| hicle Systems  |              | _     |       |     |            |     |         |                   |    |          |                     |   |         |           |        |     |                     |     |                         |
|  | 0            | 0     | 0     | 0   |            | 0   |         | 0                 | X  |          | 0                   | 0 | 0       | v         | V      | X   | 0                   | 0   | X                       |
| Lightweight Structures   |              |       | U     | ő   |            | ő   |         | ×                 | x  |          | ×                   | ŏ | ő       | X         | X<br>O | 0   | X                   | 0   | x                       |
| Deployable Systems   | _            |       | _     | - 0 | 0          | -   |         | -0                | â  |          | -0                  | ő | ő       |           | 0      | ô   | x                   | 0   | ô                       |
| Radiation Hardening / Shielding  | -            |       | _     | -   | 0          |     |         |                   |    | -        | ^                   |   | U       | X         |        | U   | X                   |     | 0                       |
| MMOD Protection  | _            |       |       | _   | 0          |     |         | X                 | X  |          | -                   | 0 |         | X         | 0      |     |                     | 0   |                         |
| Efficient Thermal Systems  | -            | -     | -     |     |            | -   |         | X                 | X  |          | X                   | 0 | 0       | Х         | 0      | 0   | Х                   | 0   | 0                       |
| Avionics/Intelligent System Health Management  | X            | X     | X     | X   | X          | X   |         | X                 | Х  |          | X                   | 0 |         | Х         | 0      | Х   | X                   | 0   | X                       |
| Power (generation, conversion, distribution)   | X            | Х     | X     | X   | X          | X   |         | X                 | X  |          | X                   | 0 | X       | Х         | 0      | Х   | X                   | 0   | X                       |
| Communications and Data Handling   | X            | X     | X     | X   | X          | X   |         | X                 | X  |          | X                   | 0 | X       | X         | 0      | Х   | X                   | 0   | X                       |
| Guidance, Navigation & Control   | X            | X     | X     | X   | X          | Х   |         | X                 | Х  |          | Х                   | 0 | X       | Х         | 0      | Х   | Х                   | 0   | Х                       |
| Reaction Control/Orbital Maneuvering   | ×            |       | X     | X   | X          | X   |         | X                 | X  |          | X                   | 0 | X       | Х         | 0      | X   | Х                   | 0   |                         |
| Cryo Fluid Management  | A CONTRACTOR | 10.0  |       | 0   | 0          | X   |         | X                 | X  |          | X                   | 0 | 0       | Х         | 0      | 0   | Х                   | 0   |                         |
| Systems Engineering and Integration (inc. M&S)   | X            | X     | X     | X   | X          | X   |         |                   | Х  |          | X                   | 0 | X       | Х         | Х      | X   | X                   | 0   |                         |
| ıman Systems   |              |       |       |     |            |     |         |                   |    |          |                     |   |         |           |        |     |                     |     |                         |
| Life Support   |              | X     |       |     | X          |     |         | X                 |    |          | X                   |   |         | Х         |        |     | X                   |     |                         |
| Radiation Protection   |              |       | 100   |     |            |     |         | X                 |    |          | X                   |   |         | X         |        |     | X                   |     |                         |
| Biomedical Countermeasures   |              |       |       |     |            |     |         |                   |    |          | 10000               |   |         | X         |        |     |                     |     |                         |
| Crew Systems; In-space   |              | X     |       |     | X          |     |         | X                 |    |          | X                   |   |         | X         |        |     | X                   |     |                         |
| Crew Systems; Surface  |              |       |       |     |            |     |         | ×                 |    |          |                     |   |         | x         |        |     |                     |     |                         |
| Artifical Gravity  |              |       |       |     |            |     |         | _^_               |    |          |                     |   |         | ô         |        |     |                     |     |                         |
| perations  | المهماني     |       |       |     |            |     |         |                   |    |          |                     |   |         |           |        |     |                     |     |                         |
| Automated  |              |       |       |     |            |     |         |                   |    |          |                     |   |         |           |        |     |                     |     |                         |
|  | _            |       | -     | Y   | Y          | Y   |         | 0                 | 0  |          | Y                   | 0 | 0       | 0         | 0      | 0   | v                   | 0   | 0                       |
| Rendezvous and Docking   | _            |       | -     |     |            | - 0 |         | ÿ                 |    |          | <b>.</b>            | 0 | ÿ       | 0         |        | Ü   | X                   | 0   | Ü                       |
| Manuevering  | _            |       |       | _ X | Х          |     |         | A                 | X  | - 1      | ^                   | 0 |         | X         | 0      | A . | X                   | 0   | X                       |
| Decision Making  |              |       | -     | 0   |            | 0   |         | 0                 | X  |          | 0                   | 0 | 0       | 0         | 0      | 0   | 0                   | 0   | X                       |
| On-Orbit Assembly and/or Repair (EVA)  |              |       |       |     | 0          | 0   |         | 0                 | X  | 1        | X                   |   |         | X         | 0      |     | X                   |     |                         |
| Launch and Payload Processing / Range  | X            | X     | X     |     |            |     |         |                   |    |          |                     |   |         |           |        |     |                     |     |                         |
| Recovery   |              |       |       | 0   | X          |     |         |                   |    |          | X                   |   |         |           |        | X   | X                   |     | X                       |
| ISRU Propellants/Fluids  |              |       | 1     |     | 1          |     |         | 0                 |    | <u> </u> |                     |   | 1       | Х         | 1      |     | 0                   | n 2 |                         |
| Propellant Transfer  |              |       |       | 0   | 0          | 0   |         | 0                 | X  |          |                     | 0 | 1       | 0         | 0      |     | 0                   | 0   |                         |
| Communications and Navigation Network  | X            | X     | X     | X   | X          | X   |         | X                 | ×  | 1 0      |                     |   |         | X         | 0      |     | X                   |     | · · ·                   |





Spiral 4/5

|  |                 |            | -614    | _  | Forth Oct   |       |        |   |                | Transport |                   |       |         |            |                |              |  |          | Cales Cuete  |
|--|-----------------|------------|---------|--|---|-------|--------|---|----------------|-----------|-------------------|-------|---------|------------|----------------|--------------|--|----------|--|
| by Transportation Capabilities                 |                 | orth To O  |         |  | Earth Orbit Human   |       |        | arth to Mo  |                |           | to Earth I        |       |         | arth to Ma |                |              | to Earth I   |          | Solar Syste<br>Robotic   |
| ansportation Elements                          | RODOGC          | numan      | Cargo   | Robott   | Human   | Cargo | Robouc | numan   | Cargo          | RODOUC    | numan             | Cargo | Robotic | Human      | Cargo          | Robout       | Human  | Cargo    | KODOBC   |
|  |                 |            |         |  |   |       |        |   |                |           |                   |       |         |            |                |              |  |          |  |
| ELV / EELV                                     | NAME OF TAXABLE | 0          | 0       | _  |   |       |        | _   |                |           |                   |       |         |            |                |              | -  | $\perp$  |  |
| EELV Derived                                   | 0               | 0          | 0       |  |   |       |        |   |                |           |                   |       |         |            |                |              |  |          |  |
| Shuttle Derived                                | 0               | 0          | 0       |  |   |       |        |   |                |           |                   |       |         |            |                |              | THE RESERVE THE RE |          |  |
| Crew Exploration Vehicle                       |                 | X          |         |  | X   |       |        | X   |                |           | X                 |       |         | X          |                |              | X  |          |  |
| Launch Escape System                           |                 | X          |         |  |   |       |        |   |                |           |                   |       |         |            |                |              |  |          |  |
| Upper Stage / Transfer Stage                   |                 |            |         | X  | X   |       |        | X   | X              |           | X                 | 0     | X       | X          | 0              | X            | X  | 0        | 100==0 Y0X=0   |
| In-Space Propellant / Supply Depot             |                 |            |         |  |   | 0     |        |   | 0              |           |                   | 0     |         | 0          | 0              |              | 0  | 0        |  |
| Planetary Capture / Entry                      |                 |            |         |  |   |       |        | X   | X              |           |                   |       | 100 X   | X          | 0              |              |  |          | X  |
| Planetary Landing                              |                 |            |         |  |   |       |        | X   | X              |           |                   |       | X       | X          | 0              |              |  |          |  |
| Surface Mobility                               |                 |            |         |  |   |       |        | X   | X              |           |                   |       | X       |            | 0              | X            | Ü.   |          |  |
| Planetary Ascent                               |                 |            |         |  |   |       |        |   |                |           | CONTRACTOR        |       |         |            |                | X            | X  |          | X  |
| Reentry at Earth                               |                 |            |         | The Name of Street, or other teams, and the street, and the st | Track et al.  |       |        |   |                |           |                   |       |         |            |                | X            | X  |          |  |
| opulsion Systems                               |                 |            |         |  |   |       |        |   |                |           |                   |       |         |            |                |              |  |          |  |
| Chemical                                       |                 |            |         |  |   |       |        |   |                |           |                   |       |         |            |                |              |  |          |  |
| Liquid   | -               |            |         |  | 1   |       |        |   |                |           |                   |       |         |            |                |              |  |          |  |
| Cryogenics                                     | X               | restX as   | X X     | 0  | 0   | 0     |        | THE REAL PROPERTY.  | X              | 97        | X                 |       | 0       | COOK 455   | 0              | 0            | X  |          | 0  |
| Storables                                      | X               | The second |         | Sec. 187   |   | ×     |        | o .   | 0              |           | X                 |       | ŏ       | o          | ŏ              | ö            | X  |          | ŏ  |
| Solid / Hybrid                                 | - x             | 0          | 0       |  |   |       |        | 0   | -              |           | 1000              |       | ŏ       | -          |                | ŏ            | A COLUMN   |          | Ö  |
|  | Ô               | ö          | 0       |  | +   |       |        |   |                |           |                   |       | -       |            |                | -            |  |          | -  |
| Launch Assist Nuclear Thermal                  | 0               | 0          | 0       |  | +   |       |        | -   | 0              |           |                   | -     | -       |            |                |              | 0  |          | 0  |
|  |                 |            | -       | -  |   |       |        |   | U              |           |                   |       |         | 0          | 0              |              | 0  | 0        | 0  |
| Electric                                       |                 |            | -       |  |   |       |        |   | Name of Street |           |                   |       |         |            |                |              |  |          |  |
| Low Power (<50kw)                              |                 |            |         | 0  |   | 0     |        | _   | 0              |           |                   | 0     | 0       |            |                | 0            |  |          |  |
| Medium Power (50-500kw)                        |                 |            |         |  |   |       |        |   | 0              |           |                   | 0     | 0       |            | 0              | 0            |  | 0        | X  |
| High Power (>500kw)                            |                 |            |         |  |   |       |        |   |                |           |                   |       |         | 0          | 0              |              | 0  | 0        |  |
| Propellantless                                 |                 |            |         |  |   |       |        |   |                |           |                   |       |         |            |                |              |  |          |  |
| Aeroassist (Capture / Entry)                   |                 |            |         | 0  | X   |       |        |   |                |           |                   |       | 0       | 0          | X              | 0            | X  |          | X X  |
| Sails  |                 |            |         |  |   |       |        |   |                |           |                   |       |         |            | 0              |              |  |          |  |
| Tethers  |                 |            |         |  |   |       |        |   | 0              |           |                   |       |         |            | 0              |              |  |          |  |
| hicle Systems                                  |                 |            |         |  |   |       |        |   |                |           |                   |       |         |            |                |              |  |          |  |
| Lightweight Structures                         | 0               | 0          | 0       | 0  | 1   | 0     |        | 0   | 4.0X           |           | 0                 | 0     | 0       | X          | X              | X            | 0  | 0        | X  |
| Deployable Systems                             |                 |            |         | 0  |   | 0     |        | X   | X              |           | X                 | 0     | 0       | X          | 0              | X            | X  | 0        | X  |
| Radiation Hardening / Shielding                |                 |            |         |  | 0   |       |        |   | X              |           | X                 | 0     | 0       | X          | 0              | 0            | X  | 0        | 0  |
| MMOD Protection                                |                 |            |         |  | 0   |       |        | X   | X              |           | and the second    | 0     |         | X          | 0              |              | Control of the Control   | 0        |  |
| Efficient Thermal Systems                      |                 |            |         |  |   |       |        | Disk Kall   | X              |           | 10 mg/(m)         | 0     | 0       | 000 X      | 0              | 0            | THE RESERVE  | 0        | 0  |
| Avionics/Intelligent System Health Management  | 6505X605        | X          | ALL YOU | X  | TOTAL NAME OF   | an X  |        | ×   | 3.5 X 100      |           | X                 | 0     |         | X          | o              | X            | X  | 0        | CONTROL X AND D  |
| Power (generation, conversion, distribution)   | X               | X          | ×       | ×  | X   | X     |        |   | X              |           | X                 | o     | A X     | X          | o              | 100          | X  | o        | The state of the s |
| Communications and Data Handling               | X               | , i        | x       | X  | X   | X     |        | ×   | ×              |           | ×                 | o     | X       | X          | o              | ×            | X  | ŏ        | 2000 X   |
| Guidance, Navigation & Control                 | X               | X          | â       | Ŷ.   | X   | x     |        | X   | x              |           | x                 | ŏ     | X       | x          | ŏ              | X            | X  | ŏ        | X  |
| Reaction Control/Orbital Maneuvering           | WILL X BUT      | 100        | X       | ×  | X   | X     |        | E X   | X              |           | E-5X              | o     | X       | No.        | ŏ              | X            | Ŷ  | ŏ        | CONTRACTOR OF THE PARTY OF THE  |
|  | 2000            |            | 1000    | 0  | o   | X     |        | CONTRACTOR OF THE PARTY OF THE | x              |           | N N X G S S       | ö     | Ô       | x          | 0              | ô            | x  | ö        | ALL STATES   |
| Cryo Fluid Management                          | No. of Xines    |            |         | _  | X   |       |        | 100 A 100   |                |           | 2000              | 0     | ×       |            |                |              | 200  |          | with X   |
| Systems Engineering and Integration (inc. M&S) | A. C.           |            |         | X  | -   | A     |        |   |                |           | The Real Property | U     | A.      | A STATE    | A Committee of |              | A.   | 0        | A Commence   |
| ıman Systems                                   |                 |            |         |  |   |       |        |   |                |           |                   |       |         |            |                |              |  |          |  |
| Life Support                                   |                 | X          |         | -  | X   |       |        | X   |                |           | X                 |       |         | X          |                | -            | No. of Concession, Name of Street, or other party of the Concession, Name of Street, or other pa | $\vdash$ |  |
| Radiation Protection                           |                 |            |         |  |   |       |        | ×   |                |           | X                 |       |         | X          |                |              | X  | -        |  |
| Biomedical Countermeasures                     |                 |            |         |  |   |       |        |   |                |           |                   |       |         | X          |                |              |  |          |  |
| Crew Systems; In-space                         |                 | X          |         |  | X   |       |        | - 1   |                |           | W.Xee             |       |         | X          |                |              | X  |          |  |
| Crew Systems; Surface                          |                 |            |         |  |   |       |        | - 10 (A)  |                |           |                   |       |         | X          |                |              |  |          |  |
| Artifical Gravity                              |                 |            |         |  |   |       |        |   |                |           |                   |       |         | 0          |                |              |  |          |  |
| perations                                      |                 |            |         |  |   |       |        |   |                |           |                   |       |         |            |                |              |  |          |  |
| Automated                                      |                 |            |         |  |   |       |        |   |                |           |                   |       |         |            |                |              |  |          |  |
| Rendezvous and Docking                         |                 |            |         | X  | X   | X     |        | 0   | 0              |           | 55112 X (200      | 0     | 0       | 0          | 0              | 0            | N. X.  | 0        | 0  |
| Manuevering                                    |                 |            |         | - X  | X   | X     |        | ×   | X              |           | L.X               | 0     | X       | X          | 0              | X            | X  | o        | X  |
| Decision Making                                |                 |            |         | 0  | 1   | 0     |        | 0   | X              |           | Ö                 | 0     | 0       | 0          | o              | 0            | X  | ŏ        | X  |
| On-Orbit Assembly and/or Repair (EVA)          | -               |            |         |  | 0   | 0     |        | 0   | X              |           | EB 40             |       | -       | X          | o              |              | No.  |          |  |
| Launch and Payload Processing / Range          | on X Sun        | CONTRACTOR | AND YOU |  |   |       |        |   |                |           |                   |       |         |            |                |              |  |          |  |
| Recovery                                       |                 | - ^        | -       | 0  | X   |       |        |   |                |           | III (X-           |       |         |            |                | X            | A STATE OF THE PARTY OF  |          | Version XX or  |
| CAMPINATE A                                    |                 |            | -       |  | DATE OF THE PARTY |       |        | 0   |                |           |                   |       |         | · ·        |                |              | 0  |          | Control of the Contro |
|  |                 |            |         |  |   |       |        |   |                |           |                   |       |         |            |                | 1            |  |          |  |
| ISRU Propellants/Fluids                        |                 |            | -       |  | - 0   | 100 A |        |   |                |           |                   |       |         |            |                |              |  |          |  |
|  | X               |            |         | 0  | 0   | 0     |        | ō   | X              |           | X                 | 0     | X       | 0          | 0              | to the later | O.   | 0        |  |



# **Analysis of Capability Need Across Spirals**



|  | 44         | - 10 C M (10 C ) | VP-00 - 100 |         |            | - 200     | un 2005 | and more and | Key Tr  | ansporta | tion Func | tions |         | TOTAL SALL POLICE |              | or when | 1.32 000   | www.  |              |
|--|------------|------------------|-------------|---------|------------|-----------|---------|--------------|---------|----------|-----------|-------|---------|-------------------|--------------|---------|------------|-------|--------------|
|  |            | rth To Or        |             |         | arth Orbi  |           |         | rth to Mo    |         |          | to Earth  |       |         | arth to Ma        |              |         | to Earth F |       | Solar System |
| Key Transportation Capabilities                | Robotic    | Human            | Cargo       | Robotic | Human      | Cargo     | Robotic | Human        | Cargo   | Robotic  | Human     | Cargo | Robotic | Human             | Cargo        | Robotic | Human      | Cargo | Robotic      |
| Transportation Elements                        |            |                  |             |         |            |           |         |              |         |          |           |       |         |                   |              |         |            |       |              |
| ELV / EELV                                     | 4/0/4      | 0/4/4            | 0/3/3       |         |            |           |         |              |         |          |           |       |         |                   |              |         |            |       |              |
| EELV Derived                                   | 0/4/4      | 0/4/4            | 0/3/3       |         |            |           |         |              |         |          |           |       |         |                   |              |         |            |       |              |
| Shuttle Derived                                | 0/4/4      | 0/4/4            | 0/3/3       |         |            |           |         |              |         |          |           |       |         |                   |              |         |            |       |              |
| Crew Exploration Vehicle                       |            | 4/0/4            |             |         | 4/0/4      |           |         | 3/0/3        |         |          | 3/0/3     |       |         | 1/0/1             |              |         | 1/0/1      |       |              |
| Launch Escape System                           |            | 4/0/4            |             |         |            |           |         |              |         |          |           |       |         |                   |              |         |            |       |              |
| Upper Stage / Transfer Stage                   |            |                  |             | 4/0/4   | 4/0/4      |           | 1/0/1   | 3/0/3        | 2/1/3   | 1/0/1    | 3/0/3     | 0/2/2 | 4/0/4   | 1/0/1             | 0/1/1        | 4/0/4   | 1/0/1      | 0/1/1 | 4/0/4        |
| In-Space Propellant / Supply Depot             |            |                  |             | 0.000   | .0.0.0.0.0 | 0/2/2     |         |              | 0/2/2   |          | 30 180000 | 0/2/2 |         | 0/1/1             | 0/1/1        | 5.07.60 | 0/1/1      | 0/1/1 | 111711710    |
| Planetary Capture / Entry                      |            |                  |             |         |            |           | 1/0/1   | 3/0/3        | 2/1/3   |          |           |       | 4/0/4   | 1/0/1             | 0/1/1        |         |            |       | 4/0/4        |
| Planetary Landing                              |            |                  |             |         |            |           | 1/0/1   | 3/0/3        | 2/1/3   |          |           |       | 4/0/4   | 1/0/1             | 0/1/1        |         |            |       | 4/0/4        |
| Surface Mobility                               |            |                  |             |         |            |           | 0/1/1   | 2/1/3        | 2/0/2   | 0/1/1    |           |       | 4/0/4   | 1/0/1             | 0/1/1        | 3/1/4   |            |       | CRONOLL      |
| Planetary Ascent                               |            |                  |             |         |            |           |         |              |         | 1/0/1    | 3/0/3     |       |         |                   | 1 6          | 4/0/4   | 1/0/1      |       | 4/0/4        |
| Reentry at Earth                               |            |                  |             | 4/0/4   | 4/0/4      |           |         |              |         | 1/0/1    | 3/0/3     |       |         |                   |              | 4/0/4   | 1/0/1      |       | 4/0/4        |
| Propulsion Systems                             |            |                  |             |         |            |           |         |              |         |          |           |       |         |                   |              |         |            |       |              |
| Chemical                                       |            |                  |             |         |            |           | 8 8     |              |         |          |           |       |         |                   |              |         |            |       |              |
| Liquid   | _          |                  |             |         |            |           |         |              |         |          |           |       |         |                   |              |         |            |       |              |
| Cryogenics                                     | 4/0/4      | 4/0/4            | 3/0/3       | 0/4/4   | 0/4/4      | 0/3/3     | 0/1/1   | 3/0/3        | 2/1/3   | 0/1/1    | 3/0/3     |       | 0/4/4   | 1/0/1             | 0/1/1        | 0/4/4   | 1/0/1      |       | 0/4/4        |
| Storables                                      | 4/0/4      | 4/0/4            | oruro       | 4/0/4   | 4/0/4      | 3/0/3     | 0/1/1   | 0/3/3        | 0/3/3   | 0/1/1    | 3/0/3     |       | 0/4/4   | 0/1/1             | 0/1/1        | 0/4/4   | 1/0/1      |       | 0/4/4        |
| Solid / Hybrid                                 | 4/0/4      | 0/4/4            | 0/3/3       | 41014   | 4/0/4      | 3/0/3     | 0/1/1   | urara        | 0/3/3   | 0/1/1    | arura     |       | 0/4/4   | 0/1/1             | 0/1/1        | 0/4/4   | 1/0/1      | -     | 0/4/4        |
|  | 0/4/4      | 0/4/4            | 0/3/3       |         |            |           | Uriri   |              |         | 0/1/1    |           | _     | 0/4/4   |                   |              | 0/4/4   |            |       | 0/4/4        |
| Launch Assist                                  | 0/4/4      | 0/4/4            | 0/3/3       |         |            |           |         |              | 0/0/0   |          |           |       |         | 0/4/4             | 0/4/4        |         | 0/4/4      | 0/1/1 | 0/4/4        |
| Nuclear Thermal                                |            |                  |             |         |            |           |         |              | 0/2/2   |          | -         |       |         | 0/1/1             | 0/1/1        |         | 0/1/1      | 0/1/1 | 0/1/1        |
| Electric                                       |            |                  |             |         |            | 21212     | *****   |              |         |          | -         |       |         |                   |              | *****   |            |       |              |
| Low Power (<50kw)                              | _          |                  |             | 0/4/4   |            | 0/3/3     | 0/1/1   |              | 0/2/2   | 0/1/1    |           | 0/2/2 | 0/4/4   |                   |              | 0/4/4   |            | ***** | 4/0/4        |
| Medium Power (50-500kw)                        |            |                  |             |         |            |           | 0/1/1   |              | 0/2/2   | 0/1/1    |           | 0/2/2 | 0/4/4   |                   | 0/1/1        | 0/4/4   |            | 0/1/1 | 3/0/3        |
| High Power (>500kw)                            |            |                  |             |         |            |           |         |              |         |          |           |       |         | 0/1/1             | 0/1/1        |         | 0/1/1      | 0/1/1 |              |
| Propellantless                                 |            |                  |             |         |            |           |         |              |         |          |           |       |         |                   |              |         |            |       |              |
| Aeroassist (Capture / Entry)                   |            |                  |             | 0/4/4   | 4/0/4      |           |         |              |         | 0/1/1    | 3/0/3     |       | 0/4/4   | 0/1/1             | 1/0/1        | 0/4/4   | 1/0/1      |       | 3/1/4        |
| Sails  |            |                  |             |         |            |           |         |              |         |          | 1         |       |         |                   | 0/1/1        |         |            |       | 3/1/4        |
| Tethers  |            |                  | l, l,       |         |            |           | l l     |              | 0/2/2   |          |           |       |         |                   | 0/1/1        |         |            | U     |              |
| Vehicle Systems                                |            |                  |             |         |            |           |         |              |         |          |           |       |         |                   |              |         |            |       |              |
| Lightweight Structures                         | 0/4/4      | 0/4/4            | 0/3/3       | 0/4/4   |            | 0/3/3     | 0/1/1   | 0/3/3        | 2/1/3   | 1/0/1    | 0/3/3     | 0/2/2 | 1/3/4   | 1/0/1             | 1/0/1        | 4/0/4   | 0/1/1      | 0/1/1 | 4/0/4        |
| Deployable Systems                             |            |                  |             | 0/4/4   | _0005      | 0/3/3     | 0/1/1   | 3/0/3        | 2/1/3   | 1/0/1    | 3/0/3     | 0/2/2 | 1/3/4   | 1/0/1             | 0/1/1        | 4/0/4   | 1/0/1      | 0/1/1 | 4/0/4        |
| Radiation Hardening / Shielding                |            |                  |             |         | 0/4/4      | LAUX CIT. | 0/1/1   | 3/0/3        | 2/1/3   | 0/1/1    | 3/0/3     | 0/2/2 | 0/4/4   | 1/0/1             | 0/1/1        | 0/4/4   | 1/0/1      | 0/1/1 | 0/4/4        |
| MMOD Protection                                |            |                  |             |         | 0/4/4      |           |         | 3/0/3        | 2/1/3   |          |           | 0/2/2 |         | 1/0/1             | 0/1/1        |         |            | 0/1/1 |              |
| Efficient Thermal Systems                      | La vinania |                  |             |         |            |           | 0/1/1   | 3/0/3        | 2/1/3   | 0/1/1    | 3/0/3     | 0/2/2 | 0/4/4   | 1/0/1             | 0/1/1        | 0/4/4   | 1/0/1      | 0/1/1 | 0/4/4        |
| Avionics/Intelligent System Health Management  | 4/0/4      | 4/0/4            | 3/0/3       | 4/0/4   | 4/0/4      | 3/0/3     | 1/0/1   | 3/0/3        | 2/1/3   | 1/0/1    | 3/0/3     | 0/2/2 | 1/0/1   | 1/0/1             | 0/1/1        | 4/0/4   | 1/0/1      | 0/1/1 | 4/0/4        |
| Power (generation, conversion, distribution)   | 4/0/4      | 4/0/4            | 3/0/3       | 4/0/4   | 4/0/4      | 3/0/3     | 1/0/1   | 3/0/3        | 2/1/3   | 1/0/1    | 3/0/3     | 0/2/2 | 4/0/4   | 1/0/1             | 0/1/1        | 4/0/4   | 1/0/1      | 0/1/1 | 4/0/4        |
| Communications and Data Handling               | 4/0/4      | 4/0/4            | 3/0/3       | 4/0/4   | 4/0/4      | 3/0/3     | 1/0/1   | 3/0/3        | 2/1/3   | 1/0/1    | 3/0/3     | 0/2/2 | 4/0/4   | 1/0/1             | 0/1/1        | 4/0/4   | 1/0/1      | 0/1/1 | 4/0/4        |
| Guidance, Navigation & Control                 | 4/0/4      | 4/0/4            | 3/0/3       | 4/0/4   | 4/0/4      | 3/0/3     | 1/0/1   | 3/0/3        | 2/1/3   | 1/0/1    | 3/0/3     | 0/2/2 | 4/0/4   | 1/0/1             | 0/1/1        | 4/0/4   | 1/0/1      | 0/1/1 | 4/0/4        |
| Reaction Control/Orbital Maneuvering           | 4/0/4      | 4/0/4            | 3/0/3       | 4/0/4   | 4/0/4      | 3/0/3     | 1/0/1   | 3/0/3        | 2/1/3   | 1/0/1    | 3/0/3     | 0/2/2 | 4/0/4   | 1/0/1             | 0/1/1        | 4/0/4   | 1/0/1      | 0/1/1 | 4/0/4        |
| Cryo Fluid Management                          | 47074      | 47074            | 01010       | 0/4/4   | 0/4/4      | 3/0/3     | 0/1/1   | 3/0/3        | 2/1/3   | 0/1/1    | 3/0/3     | 0/2/2 | 0/4/4   | 1/0/1             | 0/1/1        | 0/4/4   | 1/0/1      | 0/1/1 | 47074        |
| Systems Engineering and Integration (inc. M&S) | 4/0/4      | 4/0/4            | 3/0/3       | 4/0/4   | 4/0/4      | 3/0/3     | 1/0/1   | 3/0/3        | 3/0/3   | 1/0/1    | 3/0/3     | 0/2/2 | 4/0/4   | 1/0/1             | 1/0/1        | 4/0/4   | 1/0/1      | 0/1/1 | 4/0/4        |
| Human Systems                                  | 410/4      | 47074            | 01010       | 41014   | 4/0/4      | Ururu     | 17011   | 01010        | 3/0/3   | Trort    | 51015     | UILIL | 4/0/4   | 17011             | 170/1        | 4/0/4   | 17071      | Uriri | 47074        |
| Life Support                                   | _          | 4/0/4            |             | -       | 4/0/4      |           |         | 3/0/3        |         |          | 3/0/3     |       |         | 1/0/1             | _            |         | 1/0/1      | -     |              |
|  | _          | 4/0/4            |             |         | 4/0/4      |           |         |              |         | _        |           |       |         |                   |              |         |            |       |              |
| Radiation Protection                           |            |                  |             |         |            |           |         | 3/0/3        |         |          | 3/0/3     |       |         | 1/0/1             |              |         | 1/0/1      | _     |              |
| Biomedical Countermeasures                     | _          | 41014            |             |         | 41074      |           | _       | 0.10.10      |         | _        | 2/0/2     |       |         | 1/0/1             |              |         | 4.10.14    |       |              |
| Crew Systems; In-space                         |            | 4/0/4            |             |         | 4/0/4      |           |         | 3/0/3        |         |          | 3/0/3     |       |         | 1/0/1             |              |         | 1/0/1      |       |              |
| Crew Systems; Surface                          | - 1        |                  |             |         |            |           |         | 3/0/3        |         |          |           |       |         | 1/0/1             | -            |         |            |       |              |
| Artifical Gravity                              |            |                  |             |         |            |           |         |              |         |          |           |       |         | 0/1/1             |              |         |            |       |              |
| Operations                                     |            |                  |             |         |            |           |         |              |         |          |           |       |         |                   |              |         |            |       |              |
| Automated                                      |            |                  |             | 1       |            |           |         |              |         |          |           |       |         |                   |              |         |            | 1     |              |
| Rendezvous and Docking                         |            |                  |             | 4/0/4   | 3/1/4      | 3/0/3     | 0/1/1   | 0/3/3        | 0/3/3   | 0/1/1    | 3/0/3     | 0/2/2 | 0/4/4   | 0/1/1             | 0/1/1        | 0/4/4   | 1/0/1      | 0/1/1 | 0/4/4        |
| Manuevering                                    |            |                  |             | 4/0/4   | 3/1/4      | 3/0/3     | 1/0/1   | 3/0/3        | 2/1/3   | 1/0/1    | 3/0/3     | 0/2/2 | 4/0/4   | 1/0/1             | 0/1/1        | 4/0/4   | 1/0/1      | 0/1/1 | 4/0/4        |
| Decision Making                                |            |                  |             | 0/4/4   |            | 0/3/3     | 0/1/1   | 0/3/3        | 2/1/3   | 0/1/1    | 0/3/3     | 0/2/2 | 0/4/4   | 0/1/1             | 0/1/1        | 0/4/4   | 0/1/1      | 0/1/1 | 4/0/4        |
| On-Orbit Assembly and/or Repair (EVA)          |            |                  |             |         | 0/4/4      | 0/3/3     |         | 0/3/3        | 2/1/3   |          | 2/1/3     |       |         | 1/0/1             | 0/1/1        |         | 1/0/1      |       |              |
| Launch and Payload Processing / Range          | 4/0/4      | 4/0/4            | 3/0/3       |         | 2011/01/20 | 2/2533    |         | 10000000     | 110.000 |          | S12-0190  |       |         | 11000             | The state of |         | - WARD - 1 |       |              |
| Recovery                                       |            |                  |             | 0/4/4   | 4/0/4      |           |         |              |         | 1/0/1    | 3/0/3     |       |         |                   |              | 4/0/4   | 1/0/1      |       | 4/0/4        |
| ISRU Propellants/Fluids                        |            |                  |             |         |            |           |         | 0/2/2        |         |          | 0/1/1     |       |         | 1/0/1             |              |         | 0/1/1      |       | 200700       |
| Propellant Transfer                            |            |                  |             | 0/2/2   | 0/2/2      | 0/3/3     |         | 0/3/3        | 2/1/3   |          |           | 0/2/2 |         | 0/1/1             | 0/1/1        |         | 0/1/1      | 0/1/1 |              |
|  |            |                  |             |         |            |           |         |              |         |          |           |       |         |                   |              |         |            |       |              |

Legend:

Number of Probable / Potential / Total